TEA RESEARCH ASSOCIATION

ANNUAL SCIENTIFIC REPORT
1966

Published by
Tocklai Experimental Station
Jorhat-8, Assam, India.
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DIRECTOR'S REPORT

Organisation :

On the 31st December, 1966 the Senior Staff of the Tocklai Experimental Station consisted of:

Directorate :

Director	..	D. H. Laycock, M.B.E.,M.Sc., A.I.C.T.A.
Administrative Controller	..	J. R. Gee-Smyth
Finance & Accounts Officer	...	M. K. Choudhuri, B.Com. (Cal),A.C.A.
Station Engineer	...	G. B. Singh, A.M.I.S.E.

Soil Chemistry Department :

Soil Chemist	..	S. K. Dey, B.Sc., Assoc. I.A.R.I.

Botany Department :

Botanist	..	D. N. Barua, B.Sc., Ph.D. (Cantab), (Senior Botanist)
Plant Physiologist	..	W. Hadfield, B.Sc. Hons. (Liv.)

Agriculture Department :

Agriculturist	...	K. N. Sharma, B.Sc. Ag., M.Sc. (Banaras) Ph.D. (Mich, U.S.A), Assoc. I.A.R.I. (Senior Agriculturist)
Second Agriculturist		S. C. Barua, B.Sc. (Cal.)

Entomology Department :

Entomologist	..	B. Banerjee, M.Sc. (Cal.), M.S. (S. Illin), Ph.D. (London)

Mycology Department :

Mycologist	..	G. Satyanarayana, B.Sc. Hons. Ph.D. (Mad), F.B.S.

Pesticide Department :

Pesticide Testing Officer	..	T. D. Mukerjea, B.Sc. (Alhd.) Ph.D. (London), Assoc. I.A.R.I.

Biochemistry Department :

Biochemist	...	S. B. Deb,M.Sc. (Cal.)

Manufacturing Advisory & Tea Tasting Department :

Manufacturing Adviser and Tea Taster	...	R. Choudhury, B. Sc. (Cal)
Second Tea Taster	...	S. K. Banerjee

Engineering Development Department :

Research Engineer	...	D. N. Barbora, B.Sc. Mining, (Banaras), M.Sc. Eng. (London), D.I.C. (Senior Research Engineer)
Second Research Engineer	...	A. C. Bardalaye, B.Sc. (Eng.), (Banaras), A.M.I.E.

Statistics Department :

Statistician	...	A. K. Biswas, M.Sc. (Gau)

Advisory Departments :

Chief Advisory Officer	...	S. K. Dutta, B.Sc. Hons. (Bom), B. Sc. (Wales)
Assam South Bank :		
Advisory Officer	...	S. Basu, B.Sc.,Ag. Hons. (Delhi) Assoc. I.A.R.I.
Advisory Officer	...	S. K. Sarkar, B.Sc. (Cal), B.Sc. Ag. (Banaras)
North Bank :		
Advisory Officer	...	P. C. Sharma, M.Sc. (Banaras), Ph. D. (London), F.L.S.
Cachar :		
Advisory Officer	...	T. K. Ghose, B.Sc. Ag. (Pat) Assoc. I.A.R.I., Ph.D. (Cornell)
West Bengal :		
Chief Advisory Officer (West Bengal)	...	W.J. Grice, M.A.Dip. Ag. (Cantab)
Advisory Officer, West Bengal (Darjeeling & Terai)	...	H. Mitra, B.Sc. (Cal)
Advisory Officer (Dooars)	...	F. Rahman, M.Sc. Ag. (Bihar), Ph.D. (I.A.R.I), New Delhi.
West Bengal Experimental Station. (Mat)		
Officer-in-Charge	...	N. B. Chanda, M.Sc. (Dac), Ph.D. (Edin)

STAFF MATTERS

Appointments—Mr. S. K. Sarkar joined as an Advisory Officer on the 7th January, Mr. G. B. Singh joined as Station Engineer on the 10th January and Mr. A. C. Bardalaye as Second Research Engineer on the 8th April, 1966.

Resignations—The following officers left the Association's service during the year and left the station on the dates shown against their names: Dr. M. C. Basu on the 22nd February; Dr. S. L. Mukherjee on the 20th August.

Retirement – Mr. P. K. Barua, Botanist retired from the Association's service on the 10th November after 34 years service.

Transfer – Mr. H. Mitra moved to Darjeeling on the 2nd February to re-open the Darjeeling & Terai Branch. Dr. F. Rahman joined as Advisory Officer, West Bengal Advisory Department, Nagrakata on the 5th February. Dr. T. K. Ghose left Tocklai on the 12th March to take over advisory duties of and re-open the Advisory Office in Cachar.

Leave— The following officers had their leave during the year : Messrs. D. H. Laycock, J. R. Gee-Smyth, W. J. Grice, W. Hadfield, P. K. Barua, S. K. Dutta, D. N. Barbora, S. K. Sarkar, H. Mitra, M. K. Choudhuri, S. C. Barua, S. B. Deb, A. K. Biswas, S. K. Banerjee, S. K. Dey, Drs. K. N. Sharma, D. N. Barua, T. D. Mukerjea, P. C. Sharma, B. Banerjee, G. Satyanarayana & F. Rahman.

Visits—The Director and the Administrative Controller attended Council of Management Meetings in Calcutta on the 25th May and 28th September. Dr. D. N. Barua attended, on behalf of all staff, the 2nd Annual General Meeting of the T. R. A. in Calcutta on the 8th July. The Director attended the inaugural meetings of the Area Scientific Committees as follows :

(1)	South Bank West	.. at Tocklai on 25th October.
(2)	,, ,, East	.. at the Tingri Club on 31st October.
(3)	,, ,, Central	... at the Dibrugarh Planters' Club on 4th November.
(4)	North Bank West	... at the Borsola Club on 17th November
(5)	,, ,, East	... at the Bishnauth Club on 18th November.
(6)	North Cachar	... at the Retreat Club on 29th November.

MEETINGS

During the year under review the Director attended the following meetings :

Annual General Meetings of the
Terai Branch, I. T. A. on the 28th January;
Dooars Branch I. T. A. on the 29th January;
Surma Valley Branch I. T. A. on the 16th February;
Darjeeling Branch I. T. A. on the 26th March.

LECTURE COURSES

The following Lecture Courses were held during the year :

(1) Use of Agricultural Chemicals :

1st Course - 13th to 20th April
2nd Course - 25th to 27th April } 53 planters attended

(2) Field Management Course :

1st Course - 2nd to 6th May
2nd Course - 9th to 13th May
3rd Course - 16th to 20th May } 74 planters attended

(3) Vegetative Propagation Course :

1st Course - 6th to 9th June
2nd Course - 13th to 16th June } 43 planters attended

(4) Factory Management Course :

1st Course - 27th June to 1st July
2nd Course - 4th July to 8th July } 35 planters attended

(5) The Use of Agricultural Chemical Course :

3rd Course - 26th September to 28th September
4th Course - 3rd October to 5th Oct. } 50 planters attended

6) Miniature Manufacture Course :

1st Course - 14th to 16th November
2nd Course - 21st to 23rd November } 29 planters attended

TRAINEES

Seven candidates from T. R. A. Member gardens, one from a T. R. A. Non-Member garden and one Tea Board's employee joined and completed the One Year Training Course at Borbhetta.

Eleven employees of different Member gardens attended the Short Term Training Course on Vegetative Propagation at Borbhetta, out of which nine completed the course.

VISITORS

Some of the visitors, in addition to planters who visited Tocklai, are listed below in chronological order of their visits :—

Dr. Hussain Zaheer, Director General, C.S.I.R., New Delhi, and Mr. K. G. Krishnamurthi, Secretary, C.S.I.R.,
Shri Bhagwan Singh, I.A.S., Chairman, Tea Board,
Mr. Manubhai Shah, Union Minister, New Delhi,
Mr. Annesley Cook, M.B.E.,M.C., London, Director of Travancore Tea Estates & Mr .G .B. Shuttleworth, Supdt., Munjamallary, S. India,
Mr. J. L. Llewellyn, C.B.E., Adviser, U.T.A., London,
Dr. Maurizio Gianturco of Tenco, Instant Coffee & Teas Dvns., U.S.A.,
Mr. D. S. Bhatia, Technical Manager, Coca-Cola Export Corporation,
Mr. G. Laclavere, Institut Geographique National, Paris,
Mr. M. J. Plowden Roberts, Director of Meleng Tea Estates Ltd.,
Mr. C. H. Arthur, Walter Duncan & Goodricks Ltd.,
Sir George Mackinlay, McLeod Russel & Co., Ltd., London,
Mr. & Mrs. W. Kenneth Warren of James Warren & Co., Ltd., London,
Mr. P. Choudhuri, Jardine Henderson Ltd.,
Mr. W. Gardner Barker, Thos. J. Lipton Inc. & Miss Elizabeth Barker
Mr. R. L. Hards, Development Panel, London,
Mr. H. K. Fitz-Gerald, Alex Lawrie & Co., London,
Mr. & Mrs. M. S. Waterstone of Messrs. P. R. Buchanan & Co., U.K.,
Mr. & Mrs. F. S. Tuckfield, Tuckfields Teas, Australia,
Mr. R. B. Magor, George Williamson & Co., London,
Mr. R. Nissle, W. Germany,
Mr. J. Arbuthnot, Poulton Manor, Canterbury,
Mr. P. M. Glover, James Warren & Co., Ltd., London,
Mr. W. H. W. Coultas, Tea Adviser, Ministry Overseas Development, London,
Mrs. F. R. Bhesania, I.C.I. India Pvt. Ltd.,
Mr. & Mrs. A. K. Batlivala, Calcutta,
Mr. J. W. Craig of Messrs. James Finlay & Co., Ltd., Colombo,
Mr. N. S. Dhar of Kanan Devan Hills Produce & Co., Ltd., Munnar,
Mr. N. Abraham Varghese ,, ,, ,, ,,
Mr. J. C. Gouldsbury ,, ,, ,, ,,
Mr. P. R. A. Yearsley ,, ,, ,, ,,
Mr. Tom Wynne, Director of Messrs. Robert Timms & Co., Melbourne
Mr. G. A. Whittaker of Messrs. Gillanders Arbuthnot & Co., Ltd.,
Dr. B. Weischer, Plant Nematode Specialist, Germany,
Dr. A. S. Ganguly of Hindusthan Lever Ltd., Bombay,
Mr. J. F. Ramsden, Thomas, Cumberlege & Inskipp, Plantation House, U. K.
Mr. A. Mackay, British High Commissioner, New Delhi,
Mr. Nau Nihal Singh, Deputy Secretary, C.S.I.R.,New Delhi,
Mr. I. F. Morriss, T.R.A., Calcutta,
Dr. A. K. Banerjee of Hoechst Pharm. Ltd., Bombay,

Mr. A. Basu of Hoechst Pharm. Ltd., Calcutta,
Dr. D. K. Dutt of Rallis India Ltd., Calcutta,
Mr. S. R. Nene of I.C.I. (I) Ltd., Calcutta,
Mr. R. R. Varadachari of I.C.I. (I) Ltd., Calcutta,
Mr. D. J. L. Taylor of George Williamson Africa Ltd., Nairobi, Africa,
Mr. P. C. Simms of Balmer Lawrie & Co., Ltd.,
Mr. J. D. Willis of Balmer Lawrie & Co., Ltd.,
Mr. F. R. J. Bagley of McLeod & Co., Ltd.,
Mr. A. F. Macdonald, Chairman, T.R.A.,
Prof. V. Bojnansky of Czechoslovakia.

OFFICE STATISTICS

Correspondence — 14,010 letters were received and 13,764 were despatched during the year.

Library — 115 books, 315 pamphlets, 1,231 journals, 2 reprints, 1 photocopy, 6 micro copies, 6 maps and 1 translation were received by the Tocklai Library.

PUBLICATIONS

PUBLICATIONS

The following articles by the Tocklai Experimental Station's Scientific Staff were published in Indian and foreign scientific journals.

1. Banerjee, B. (1966) : Critical application of logistic principle on the laboratory population of *Anthrenus flavipes* Lec. *Indian J. Entomol.*, **28** (3) : 359 - 361.

   (Abs. The population growth of the laboratory cultures of *Anthrenus flavipes* follows the logistic principle. Population increases slowly and a peak is reached where it remains constant for a long time. After 19th week the population starts declining. After a brief interval it starts to increase again to reach the upper asymptote. The population growth and decline appear to be cyclic and in each cycle the logistic principle is additive. The population decline is brought about by intraspecific struggle, by the decrease in the fecundity of the female in succeeding generations with time and also by limitation of space.

2. Banerjee, B. (1966) : A statistical study of the population of the Tropical mound building termite *Odontotermes redemanni* (Wasmann). *Insectes Sociaux* , **13** (1) : 29-38.

   (Abs. A statistical analysis of the population of the tropical mound building termite, *Odontotermes redemanni*, shows the existence of significant peaks in the populations of worker, soldier and nymphs in different phases during June to September. The population trends of the sexual nymphs and others show a close parallelism and the associationship is quite significant from a biological point of view. The population structure within the mounds is intimately associated with the multiplicative phase of the mounds and the peak in the overall population mostly occurs when sexual nymphs are produced in large numbers. These sexual nymphs develop into alates and fly out to establish new colonies. The ability of the de-alate sexuals in the mounds to produce the sexual nymphs and other castes in large numbers during the multiplicative phase of the mounds is probably genetically determined. Various statistical tests have been tried to interpret the biological factors associated with the population dynamics of this termite.)

3. Banerjee, B. (1966) : Taxonomy , ecology and control of tea chest panel borers in warehouses. *Symp. Bionomics & Control of Pests* : **10-12**.

(Abs. *Heterobostrychus aequalis* Waterh., *Dinoderus minutes* Fabr., *Sinoxylon anale* Lesne (all belonging to the family Bostrychidae), *Lyctus* sp. (Lyctidae) and a cerambycid borer have been recorded to infest tea chest panels. All these species have undergone structural modification to enable them to bore through the wood. *Lyctus* sp. oviposits on cut or exposed surface of the wood but in the other species females tunnel to lay eggs inside. Soon after hatching, the larvae of all species tunnel through the wood. Each species has its characteristic tunnel architecture. Grubs are more active at night than in day. Larval activity increases under high relative humidity. Crowding intensifies intraspecific competition and delays the development of the grubs. Godowns, particularly the cracks and crevices on all woodwork, should be first properly cleaned and then thoroughly sprayed with DDT 50% W. P. Infested panels should be staggered and subjected to a heat treatment for about 10 minutes at 90 - 120° c. This will kill all the grubs and eggs inside the tunnels. Treated panels should not be stocked in the same godown where the infestation had occurred unless the godown has been properly cleaned and sprayed with DDT.)

4. Banerjee, B. (1966) : A review of research on plant protection methods in Tocklai. *Proc. Sem. Control of pests and diseases of tea* (Tea Board).

(Abs. Losses due to pests and diseases in North East India are considerable. The incidence of pests and diseases and their intensity of attack vary from place to place. About 300 species of insects and mites, and 190 disease causing fungi from tea and ancillary crops have been recorded, though all of them may not cause heavy losses. The roles of pests and diseases in the biological firmament distribution and abundance, population regulating mechanisms, population cycles, life-histories, host specificity and behavioural responses - are to be taken into consideration to get the best in pest control operations. Application of pesticides to tea which presents serious problems should also be considered. Aphis, thrips, tea helopeltis, scale insect and mealy bugs, cockchafer grubs, termites, looper and bunch caterpillars, four species of mites and three species of eelworms are important pests. Black rot, blister blight, grey blights, red rust, thorny blight, charcoal stump rot and brown root rot are the important diseases. DDT, Endrin and Dieldrin against insects, a few nematicides against eelworm, some synthetic organic acaricides against mites and copper fungicides against fungus diseases are of use.)

5 Barua, D. N. (1967) : Use of growth substances for vegetative propagation of the tea plant (*Camellia sinensis* L) in Northern India. *Proc. International Symposium of Plant Growth Substances.* Calcutta. Abs. 3. 2.

(Abs. The single-leaf internode cutting is the most efficient type of cutting for large-scale vegetative propagation of the tea plant under commercial conditions. Treatment of such cuttings with various growth substances, either in pure form or as proprietary formulations, did not produce significant improvement in strike. However, low concentrations (25 - 100 ppm) of indolyl -3 butyric acid (IBA) generally had beneficial effects on shoot growth but these improvements were not noticeable at higher concentrations (200 ppm). Treatment of cuttings with zinc counteracted the inhibitory effect of the higher concentration of IBA on the shoot growth of an experimental clone. Cuttings treated with IBA rooted earlier, and the root weight even after seven-nine months, with some exceptions, was significantly higher than the untreated controls.

Spraying of complete nutrient solutions on mother bushes of a clone which roots with difficulty improved the strike of its cuttings, but this effect was not noticed on clones which root well. Poor development of roots on tea cuttings propagated under optimum physical conditions may, therefore, be associated with either deficiency or imbalance of some of the inorganic constituents in the plant.

It is concluded that growth substances are unnecessary for propagating easy rooting tea clones under commercial conditions. When conditions for propagation are unfavourable and a small number of plants are required for special purposes, then tea cuttings may justify treatment with low concentrations of IBA. Cuttings with a basal node are more responsive to hormone treatment than the internode cuttings.)

6. Mukerjea, T. D. (1966) : Endrin for control of Looper Caterpillar *Biston suppressaria* Guen. on Tea. *Indian Agriculturist.* **9** (2) July : pp. 91-99.

(Abs. Laboratory and field tests with Endrin and DDT in different concentrations for control of looper caterpillars are reported. Comparative toxicity test indicated the following descending order of effectiveness. Endrin 1 in 1000 parts,

Endrin 1 in 1500 parts, Endrin 1 in 2000 parts, Endrin 1 in 2500 parts, Endrin 1 in 3000 parts, DDT 1 in 200 parts and Endrin 1 in 4000 parts of water. In laboratory as well as in field tests Endrin was much quicker in action than DDT. DDT gave poorer results than Endrin in all concentrations except Endrin 1 in 400 part of water.)

7. Mukerjea, T. D. (1966): Chemical Control of Root-knot Nematodes parasitic on tea seedlings in North-East India. *Tropical Agriculture*, Trin., **43** (4) October : pp. 335-340.

(Abs. During a period of three years, experimental field plots were established in commercial estates in Assam utilizing various soil fumigants and nematicidal chemicals for the control of the root-knot nematode, *Meloidogyne incognita acrita* and *M. hapla*. Results based on root-galling and usable transplants indicate that Nemagon, Nematox, Nematox in combination with Basudin, Basudin alone and Vapam in different doses gave a significant degree of control of root-knot nematodes as compared with untreated control plots. In experiments Nos. 1 and 2 all plants grown in treated plots had higher mean plant weights and the root-knot index showed that plants in all treatments had significantly less galling than did those in the control. There were, however, no significant differences in effectiveness between Nemagon, Nematox and Vapam.)

8. Mukerjea, T.D. (1966) : Systemic Insecticides for the control of Tea Seed bug (*Poecilocoris letus* Dall. in Tea (Abs). *Proceedings of the Seminar on Entomology Dept. of Zoology, Aligarh Muslim University*, Oct. 29 to 31, PP 53-54.

(Abs. Two organophosphatic insecticides were tried against Tea seed bug (*Poecilocoris letus* Dall) in the laboratory and in tea seed *baries* (gardens). Laboratory tests showed that Rogor and Ekatin were effective in controlling nymps and adults of Tea seed bugs. In the field investigation different doses or dilutions of Rogor and Ekatin were tried and it has been shown that Rogor at 1 in 300 parts and Ekatin at 1 in 200 parts of water were equitoxic.)

9. Sen, A. R., Sarkar, A. R. and Chakraborty, R. P. (1966): Sample surveys of pests and diseases of tea in North-East India, *Experimental Agriculture*, **2** (3) July : pp. 161-172

(Abs. Estimates of the area affected by all pests and diseases, and by Red spider (alone), showed wide variation among circles. Road-side bushes were most affected by Red spider, and Black rot was found to thrive most on bushes near jungles or bamboo baries.

The incidence of the major pests and diseases was observed to reach a peak during the months May, June and July.

Tea bushes on loamy soil were less susceptible to severe infestation by Red spider than on other soil types, and the severity of the pest was influenced by cultural practices such as shade status, drainage system, time of pruning and nature of cleaning out after pruning. Sections having good shade and good drainage, which were pruned between the beginning of November and the first week of December, and which were cleaned out properly, were less susceptible to Red spider than those under poor shade, with inadequate drainage, pruned later and with poor or no cleaning out.

The loss of tea crop due to all pests and diseases in the Assam valley during 1959 was estimated at 85 kg of made tea per hectare, which accounted for 5-6 per cent of the pest-free crop, and in the Dooars during 1960-61 at 127 kg of made tea per hectare, which was 9-10 per cent of the pest-free crop.

The corresponding loss in money value ranged between Rs. 85 and Rs. 255 in the Assam valley and Rs. 127 and Rs. 381 in the Dooars respectively, despite the control measures taken by the estates.

The annual costs per hectare on material and machinery for plant protection measures were estimated at about Rs. 8 and Rs. 5 respectively for the Assam valley, and about Rs. 12 and Rs. 3 respectively in the Dooars.)

10. **Sen, A. R.**, Sarkar, A. R. and Chakraborty, R. P. 1966): Sampling Techniques for estimation of incidence of Red Spider mite on Tea Crop in North-East India. *Biometrics*. **22** (2) June : pp. 385-403.

(Abs. Sampling techniques are described for estimating the degree of infestation of pests in tea estates, with particular reference to Red spider mite in North-East India. The discussion is based

on information obtained from preliminary surveys already described (Sen and Chakrabarty (1964). Estimation of infestation is considered both for an individual estate and a region, and problems of optimal allocation within an existing administrative framework are discussed.

An experiment on investigator bias is described : it was found that even after a substantial amount of training in identification of pests and diseases of tea, scores for infestation given to affected bushes varied significantly from one investigator to another, suggesting the need for still more training and testing before the investigators undertake definitive fieldwork. Systematic sampling of bushes from within a section of an estate is shown to be at least as efficient as any alternative sampling scheme, for the same sample size.

The possible gains due to double sampling, using a combination of eye estimation of incidence in a section with scoring of bushes for a sub sample of sections, are discussed.

Estimated optimal schemes are given, using both single and double sampling, for estimation of an index of infestation expected to be in the neighbourhood of 16%, with coefficients of variation of 5 and 10%.

11. Sen, A. R. and Biswas, A. K. (1966). Some techniques of experimentation with tea in North-East India. *Experimental Agriculture* **2** (2) April : pp. 89-100.

(Abs. An attempt is made to investigate some techniques of experimentation, based on data from uniformity trials and experiments on tea conducted in different regions of North-East India. The study showed that :

i. Adjustment of yield due to covariance generally ceased to be efficient after the first four years of experimentation in manurial trials and after two years in pruning trials. Adjustment based on average yield over a period of four to six years resulted in an increase in efficiency.

ii. Among the ancillary variables of pretreatment yield and pruning weight, the former proved to be generally more efficient , but when cost of operation is taken into account the latter was economical, and, therefore, preferable. The two variables together,

in a multiple regression, did not show any extra gain. Use of the pretreatment late crop, from September to December, was generally more efficient than using the whole season's crop.

iii. Coefficient of variation showed a declining tendency with age, the fall being more marked up to six years of age. This suggests that, for a given degree of precision, more replication would be required for experiments with young tea than with mature tea.

iv. Increase in plot size, up to 48 bushes, resulted in an increase in information per replicate in Darjeeling, though plots of smaller size would be more economical.

v. On the basis of five uniformity trials in the Assam valley, Darjeeling and Cachar district, it was observed that for the same values of cost components proportional to number of replications and total area under experiment, the optimum plot size in Darjeeling and Cachar was about half that for the Assam valley.

vi. Long and narrow plots, oriented with their longer sides extending along the contour lines, within blocks of which the longer sides ran down the slope, proved more efficient than other alternatives in Darjeeling district.

vii. Systematic plucking of 1 in 2 out of the totality of plucking rounds, for experiments running for two or more years, provided estimates of treatment contrasts within 5 per cent of the population mean ($P = 0.05$). For a higher margin of error, of 10 per cent of the mean, systematic pluckings of 1 in 3 or even 1 in 4 would suffice if the treatment comparisons were based on five or more years.)

12. Sen, A. R., Biswas, Ajit K. and Sanyal, D. K. 1966 : The Influence of Climatic Factors on the yield of Tea in the Assam valley ; *J. Applied Meteorology*, American Meteorological Society, **5** (6), December, pp. 789-800.

(Abs. An attempt has been made in this paper to study the effect of the climatic factors on the growth of the annually pruned tea and its components (a) the early crop i. e., crop plucked from the beginning of the season till June, (b) the main crop during July to September which constitutes about 50% of the total crop and (c) the late crop obtained during the rest of the season from October to December.

Data from two sources have been considered (1) long-term crop and weather data at Tocklai based on 21 years (1921-41) and (11) short-term data on yield and rainfall covering 31 estates of the Assam valley based on 7 years (1957-63).

A study of long-term data at Tocklai on soil moisture, rate of evaporation and rainfall in relation to the crop suggested that the season could best be divided into four time groups, (a) the dry period during the cold weather from January to March, (b) the period of early rains from April to June, (c) the period of main rains from July to September and (d) the dry period from October to December.)

2. The following publications were issued from Tocklai :

(1) "Two and A Bud" (Newsletter) Vol. 13, Nos. 1, 2, 3 and 4.

(2) Summarised Annual Report for 1966 (Circulation restricted).

(3) Annual Scientific Report for 1965.

(4) Quarterly Scientific Report for 4th Quarter ending 31st December, 1965. (Circulation restricted)

(5) Proceedings of Symposium on Vegetative Propagation held in Darjeeling by Dr. D. N. Barua. (Circulation restricted).

(6) Proceedings of the 22nd Annual Conference held at Tocklai. (Circulation restricted)

Tea Encyclopaedia Serials (Revised)

(7) 8 3 Black Rot

(8) 78 2 Cricket Control

(9) 111 2 Silviculture of Shade

Tea Encyclopaedia Serials (New)

(10) 168 The use of Herbicides in Tea for the control of *Mikania micrantha*

(11) 169 Levelling-off, Light and Medium skiffs

(12) 170 Deep Skiffing of Tea

REPORT OF DEPARTMENTS

SOIL CHEMISTRY DEPARTMENT

S. K. DEY— Soil Chemist

With the introduction of the revised programme of work, the main emphasis has been shifted from leaf to soil analysis, with the object of preparing soil test summaries on a regional basis to define the fertility status of soils under different ages of tea. It is hoped that these values will offer a rational basis for advisory purposes. Both physical and chemical factors are being examined.

Concurrent with this change, departmental activities have been broadly reorganised under the categories, namely (a) soil and agricultural chemistry and (b) soil physics and agricultural meteorology. Research activity has suffered in the past because of inadequate facilities, but remodelling of both the soil chemistry and soil physics laboratories is now almost complete, and this should speed up routine analytical procedures. Nevertheless it is a pleasure to record that although the year proved a considerable strain and progress of construction and procurement of equipment was undesirably slow, it proved to be potentially fruitful because a sound basis was laid for the development of future research.

From the intensive leaf analysis data gathered in the past reliable and critical values for the major nutrients cannot be established upon which fertiliser recommendations can be offered. Moreover the analytical data are often difficult to interpret because of their interplay with many factors. Carefully controlled sampling and refined technique of tissue analysis have done little to improve matters. However, foliar analysis will continue to be used particularly for those situations where the advisory problem suggests a need.

RESEARCH AND EXPERIMENT

SOIL PHYSICS

(S. 9) (a) and (b) Setting up of soil physics laboratory and establishing analytical methods and comparative survey :

1. **Structure measurement**—An analytical method has been established for the measurement of soil aggregates of varying sizes and has been extensively used for a survey project as well as for occasional routine soil samples from the estates. The consistency of the method has been tested statistically from repeat analysis of the aggregates of various sizes. The statistical analysis showed that by using this method, percentage of the soil aggregates of various sizes can be estimated with equal precision.

The coefficient of variation of the estimates of soil aggregates under different treatments was found to vary between 0 to 20 per cent, irrespective of the sizes of the aggregates. Some of the results of aggregate analysis from various situations are presented in Table 1.

Table I. Aggregate analysis of soils (top 30 cm Aggregate sizes expressed as per cent on dry weight)

Area	Description	> 5 mm m ± S.E	5-2 mm m ± S.E	2-1 mm m ± S.E	1-0.5 mm m ± S.E	0.5-0.25 m ± S.E	Total% m ± S.E
1. Scientific Department, J.T.C.L. Under *Mimosa*	Museum Grass Plot Age 2 years, previously used for cutting planting	4.94 ± 0.754	6.90 ± 0.611	6.11 ± 0.116	7.16 ± 0.552	9.45 ± 0.139	34.56
Under *Trypsacum laxum* (Guatemala grass)	Age 10 years	16.04 ± 0.257	20.65 ± 0.694	10.31 ± 1.020	9.73 ± 0.367	8.90 ± 0.574	65.63
Under *Eragrostis* (weeping love grass)	Age 1 year, previously the area was lying fallow under secondary grass	5.10 ± 0.00	10.41 ± 0.058	7.94 ± 0.587	10.19 ± 0.762	12.73 ± 0.040	46.37
Under *Crotalaria* (Borbhetta Field Station), area 45·47	Age 5 years, annual green-cropping previously under old tea	6.60 ± 0.360	15.09 ± 0.017	7.10 ± 0.037	7.31 ± 0.040	11.66 ± 0.137	47.76
2. Bamboobari near museum grass-plot, J. T. C. L.	More than 25 years	15.35 ± 0.364	24.18 ± 0.427	14.96 ± 0.655	3.66 ± 0.040	6.70 ± 0.591	69.85
3. Bare plot, near museum grass plot, J. T. C. L.	Kept as such, for 2-3 years. Previously used for propagation work	4.27 ± 0.687	6.80 ± 0.182	2.71 ± 0.160	2.47 ± 0.243	4.05 ± 0.284	20.30
4. Bare plot, near Borbhetta 11.2	Fallow land, previously grazing ground	0.55 ± 0.080	2.95 ± 0.137	4.22 ± 0.629	4.61 ± 0.222	7.99 ± 0.186	20.32
5. Tea unshaded, near museum grass plot, J. T. C. L.	Old replanted site, tea planted in 1951	1.40 ± 0.417	4.41 ± 0.222	3.03 ± 0.237	3.22 ± 0.221	4.25 ± 0.449	16.32
6. Tea, unshaded, Borbhetta area 34.17. Exptl. treatment given for 1 yr. only. Tea approx. 40 yrs.	(a) Pruning litter not removed	4.63 ± 0.034	9.47 ± 0.737	5.18 ± 0.127	4.07 ± 0.280	5.36 ± 0.390	28.71
	(b) Pruning litter removed	2.18 ± 0.168	6.00 ± 0.535	3.62 ± 0.150	3.57 ± 0.015	3.67 ± 0.015	19.04
7. Tea, unshaded, Tocklai meteorological plot, prunings stolen	Age ? Old replanted site, tea planted in 1950	0.44 ± 0.068	2.33 ± 0.152	1.66 ± 0.107	3.43 ± 0.230	6.43 ± 0.238	14.29

Data presented in Table 1 also show that the soil aggregates decrease appreciably as we go from bamboo bari to unshaded old tea or bare fallow land. Soils under grass or leguminous crops appear to have a good state of soil aggregation. There has been a fall from 29 to 19 per cent in the aggregation value of the top foot of soil following the removal of pruning litter for but one year from 40 year old tea at Borbhetta. The treatments examined are not comparable in age, but note the range of differences taking bamboobari soil as the starting point and yardstick.

Subsoil data from similar situations also show a very much similar trend in the changes of soil aggregates with treatments. Data are presented in the Table 2.

Table 2. Comparison of the percentages of total soil aggregates in the top and subsoils under various treatments (data expressed on oven dry weight basis).

Treatments	Percentages of total soil aggregates, 0.25 to 2.5 mm	
	Top soil 0–30 cm	Subsoil 30–60 cm
Bamboobari, over 25 year old :	70	63
Guatemala grass, over 10 year-old :	66	46
Weeping love grass, nearly one year old :	46	41
Mimosa, 2 year old :	35	41
Bare soil :	20	21
Unshaded tea, replanted 1951 :	16	23

A survey was conducted at Hunwal T. E. near Tocklai to examine soil aggregation on clear-felling jungle areas and adjacent fields which had been under tea for varying lengths of time. The truly virgin jungle was found to be high in total percentage aggregates with a value of 70 per cent which is of the same order as that of 63 per cent for the bamboobari soils shown above. This survey also suggests that when virgin jungles are clear-felled before planting tea, soil aggregates collapse probably as a result of these being exposed to the beating action of rain as well as due to rapid destruction of soil organic matter caused by direct insolation. But once a complete ground cover of tea or cover crop is established, no further deterioration in soil aggregates takes place. A substantial increase in the total percentage of soil aggregates was also observed between the medium age and old

tea with the progressive incorporation of pruning litters back into the soil as the tea grew older. Thus in spite of the loss of structure in the preliminary years, good management of tea, whereby organic matter is returned to the soil, offers an unique opportunity of restoring the physical condition of the soil towards its virgin status. Subsoil aggregates appear to be less sensitive to management practices.

2. **Texture measurements**—Our aim is to find out (a) whether all the profile samples of different sites are basically same from the textural point of view, and (b) whether mechanical analysis can provide a supporting evidence towards soil aggregate behaviour with the periods of cropping.

As far as (a) is concerned, for all practical purposes, soils of the different sites included in this study can be classified under the same textural class. The observed changes in soil structure are, therefore, independent of the textural property and are brought about by cultural practices.

As far as (b) is concerned, mechanical analysis results do follow the same trend with the period of cropping, as has been observed in the case of soil aggregates. Data are at present being critically examined and, as such, detailed report on this aspect is kept in abeyance.

3. **Single value physical constant measurement :**

(i) **Collection of undisturbed cores of top soil**—Hand samplers have been fabricated locally, based on the design published by the Physics Division of the East African Agriculture and Forestry Research Organisation. By these samplers standard soil cores of 10 cm diameter and 7.5 cm depth occupying a volume of 574 cc. can be collected.

(ii) **Volume-weight measurement**—Volume-weight measurements are being made on a large number of core samples together with structure and texure measurements. Results show that "old tea" soils are appreciably more compacted as compared with either virgin or young or medium age tea soils. The order of compaction seems to be very much the same at all depths of sampling, namely 10, 30, 60 and 90 cm respectively. It is, however, difficult to understand how in spite of the increased soil aggregation of the "old tea" soils, they are more compacted than either "young or medium age" tea soils. Volume weight measurement also provided us data for expressing the nutrient contents of soils on kg per hectare basis.

(iii) **Pore-space distribution**—An abortive attempt was made to determine the total porosity of soils in an indirect way from specific gravity and bulk density data using the equation

$$P = \left(1 - \frac{D}{S}\right) \times 100$$, where P = total pore space, S = specific gravity and D = bulk density. In lieu of sophisticated equipment, an estimate of Field Capacity moisture percentage was attempted for each of the soil cores collected by using a method suggested for forest soils by Wilde and Voigt (Soil and Plant Analysis for Tree Culture, 1964, Oxford publication). The results, however, are not promising, most probably because the method does not provide for draining out excess moisture from the saturated soil cores at $\frac{1}{3}$ atmosphere.

Some essential soil physics equipment is awaited from Colombo Plan sources, and it is hoped to make other items on the station with the help of the Research Engineer.

(S. 10/a). **Soil water :**

Both moisture content (gravimetric soil moisture estimate) and moisture tension (gypsum block measurement) have been measured at weekly intervals in three irrigation trials namely B 28, B 29 and B. 106 4 at Borbhetta Field Station, beginning from the cold weather of 1965 until the first week of April, 1967. These trials are conducted by the Agriculture Department.

Cylindrical gypsum blocks are made by this Department, according to the method recommended by the East African Agriculture and Forestry Research Organisation. Gypsum blocks are tested against moisture tensions under laboratory conditions prior to installing them in fields. A close agreement has been observed between the behaviour of different blocks as will be observed from the following table.

Table 3 (a). Relation between moisture tension (resistance) and moisture content of home made gypsum blocks, under laboratory conditions

Moisture meter reading (resistance) x 10^3 ohms	Percentage moisture content of gypsum blocks						
	Block 1	Block 2	Block 3	Block 4	Block 5	Block 6	Mean
100	48.4	49.1	50.6	47.2	56.4	51.7	51.1
90	46.0	45.6	46.4	43.0	48.2	48.2	46.2
80	40.2	40.2	42.2	37.2	40.6	43.4	40.6
70	33.1	33.7	31.8	32.3	37.6	33.3	34.2
60	23.9	23.0	25.0	22.5	26.4	25.8	24.4
50	17.1	15.7	15.7	13.2	18.9	18.4	16.5
40	12.0	10.7	13.6	8.8	14.2	14.4	12.3
30	8.6	8.4	9.4	7.1	10.8	8.6	8.8
20	3.9	2.4	4.6	2.0	3.4	4.0	3.6

Four gypsum blocks were placed at Tocklai in one square foot area at a depth of 15 cm together with an expensive imported block to serve as the check. The blocks were placed and left *in situ* during the dry season of 1966/67. Irrigation was given in the beginning to bring the soil to Field Capacity. Simultaneous measurements of the gravimetric soil moisture content and the moisture tension were made. From the time the plot was brought to Field Capacity it was allowed to dry until it nearly reached estimated Wilting Point. Data presented in Table 3 (b) show a close agreement between the readings obtained from home made blocks and the imported block. Though the range of soil moisture content between Field Capacity and Wilting Point is narrow, yet the drying curve seems to follow the theoretical pattern.

Table 3 (b). Relationship between moisture tension (resistance) and soil moisture content with home made and imported gypsum blocks placed at a depth of 15 cm.

Date of observation	Meter Reading (Resistance x 10^2 ohms)					% soil moisture content
	Imported block	Block 1 (home made)	Block 2 (home made)	Block 3 (home made)	Block 4 (home made)	
1.11.66	100	95	100	90	90	17.4
7.11.66	100	95	100	95	90	17.4
15.11.66	100	95	100	90	90	15.9
21.11.66	95	95	95	95	95	14.0
2.12.66	90	90	82	92	90	13.0
9.12.66	76	85	86	85	86	12.0
16.12.66	73	84	83	81	83	11.4
23.12.66	72	82	82	79	82	10.9
30.12.66	47	56	56	54	56	10.6
3.1.67	34	40	40	37	40	10.0
10.1.67	32	34	36	33	35	10.0
17.1.67	24	21	23	21	21	9.0
25.1.67	18	18	18	18	18	8.0
8.2.67	10	8	8	8	8	8.1

From the above it is possible that for this particular soil the Field Capacity moisture content is about 17 per cent on a dry weight basis, and Wilting Point about 8 per cent.

However, gypsum blocks when installed at depths between 1 to 7 feet at Borbhetta irrigation trials, and left in position from November, '65 to January, '67, which period covered both dry and monsoon conditions, yielded tension data which completely failed to show a consistent relationship with gravimetric soil moisture contents. The reason for this unexpected and erratic behaviour has not yet been explained, and is under intensive investigation. At the time of writing it seems possible that gypsum disintegrated during the monsoon period when the soils are continuously very wet.

It is quite clear that under Borbhetta conditions at least resistance measurements as at present taken cannot be used to give an indication of the soil moisture status.

The soil moisture content was estimated gravimetrically for one season from the non-irrigated plots of experiment B. 106, 1. The data show that the soil water use is higher in the case of unpruned than in the case of pruned tea, irrespective of the depths of sampling. However, similar estimations made in the single plot trial Expt. B 29, at each one foot layer to a depth of seven feet showed no difference in the soil moisture content of pruned and unpruned non-irrigated plots during the period January to March, '67.

Another unexpected observation was made in the irrigation trial B.106 4, where even in the irrigated plots soil water use had been found to be higher in the unpruned than in the pruned tea. However, the differences are not as wide as is the case with the non-irrigated pruned and unpruned teas. Data are now being statistically analysed. The differences in the soil moisture content in terms of cm of water between pruned and unpruned teas under both irrigation and no-irrigation treatments are shown in Table 4 (data from field experiment B. 106 4).

Table 4. *Gravimetric soil moisture content of a 90 cm (3 feet) soil profile as affected by the treatments (Data given in cm/ha ;* **within bracket** *figures are in./acre). Data from experiment B 106/4.*

Treatments	Date of measuring soil moisture content													
	2/1	9/1	23/1	30/1	6/2	13/2	20/2	27/2	6/3	13/3	20/3	3/4	10/4	24/4
Non-irrigated unpruned :	36 (6)	30 (5)	30 (5)	27 ($4\frac{1}{2}$)	24 (4)	30 (5)	30 (5)	36 (6)	27 ($4\frac{1}{2}$)	27 ($4\frac{1}{2}$)	36 (6)	36 (6)	30 (5)	48 (8)
Non-irrigated pruned	36 (6)	36 (6)	36 (6)	33 ($5\frac{1}{2}$)	36 (6)	39 ($6\frac{1}{2}$)	42 (7)	54 (9)	36 (6)	39 ($6\frac{1}{2}$)	48 (8)	42 (7)	36 (6)	54 (9)
Irrigated unpruned :	36 (6)	42 (7)	45 ($7\frac{1}{2}$)	42 (7)	45 ($7\frac{1}{2}$)	48 (8)	48 (8)	48 (8)	39 ($6\frac{1}{2}$)	42 (7)	45 ($7\frac{1}{2}$)	42 (7)	36 (6)	54 (9)
Irrigated pruned :	42 (7)	48 (8)	54 (9)	48 (8)	54 (9)	48 (8)	54 (9)	48 (8)	45 ($7\frac{1}{2}$)	48 (8)	48 (8)	42 (7)	42 (7)	48 (8)

The strange and unexpected behaviour of block and gravimetric readings taken from field trials which spaned both the dry and wet seasons is disappointing and aggravating. Clearly time will now have to be spent on diagnosing and rectifying the causes of the troubles and satisfactory conclusion will probably not be possible until the arrival of the sophisticated soil physics equipment. Inevitably our planned research programme must fall behind schedule because of these unforeseens.

(S. 10.) (b) Water table measurement :

Weekly ground water table measurements at Tocklai and Borbhetta (3 miles from Tocklai) were carried out during last year and these data were compared against weekly rise and fall of the Brahmaputra river level. The latter is 13 kilometers from Tocklai as the crow flies. From the present ground survey levels the Brahmaputra level in January was found to be 400 cm (13 ft. 4 in.) below the ground water table at Tocklai and Borbhetta, but during the monsoon between July and September, there appeared to be very little difference between the Brahmaputra level and the other two. Because of the potential significance of these preliminary findings apropos drainage methods and problems on estates, an accurate ground survey is planned to establish exact reference levels for the three sites.

Ground water tables below the soil surface at Borbhetta or Tocklai have been found to fluctuate between roughly 90 cm (3 feet) during the monsoon and 210 cm (7 feet) during the cold dry weather, whereas the Brahmaputra relative level fluctuates between 90 cm (3 feet) during the monsoon and 600 cm (20 feet) during the cold dry weather.

Water table measurements are now being carried out on the North Bank and in Cachar through the co-operation of the Advisory Officers.

Agricultural Meteorology

(S.8) (a) Penman analysis :

Meteorological data, collected at four sites, representing the major tea growing areas, have been used with Penman formulae to give estimates of evaporation. In due course, it is hoped these estimates, when used in conjunction with soil water studies, will give information on the transpirational requirements of tea in the various areas. Table 5(a) shows the Penman estimates of evaporation according to site and month.

Table 5. (a) Penman estimate of evaporation (E_o) from weather data for different meteorological stations in North East India. Monthly mean estimates of evaporation for the 6 years **(1960 –65)** *and their coefficients of variation*

Month or period	Penman estimate, E_o, mm/month							
	Tocklai (Assam)		Silcoorie (Cachar)		Nagrakata (Dooars)		Nagri Farm (Darjeeling)	
	Mean	C.V. %	Mean	C.V.%	Mean	C.V.%	Mean	C.V. %
January	63	2.2	79	3.1	72	4.4	59	3.8
February	85	3.0	98	4.8	97	4.7	77	3.6
March	130	2.5	142	4.7	146	3.2	123	2.9
April	146	5.3	160	5.0	168	4.0	135	4.9
May	151	2.8	175	2.2	182	3.8	137	3.1
June	149	3.7	145	3.7	137	2.8	115	2.4
July	156	4.0	150	5.4	133	4.8	110	4.8
August	141	4.4	151	4.6	134	5.1	112	4.8
September	138	2.0	146	4.2	133	2.4	109	3.6
October	120	3.9	130	2.1	131	2.9	107	2.7
November	83	2.3	99	0.5	97	1.8	75	3.9
December	63	1.5	77	2.8	73	2.3	58	3.1
Dry period	424 mm 17 in.		495 mm 20 in.		485 mm 19 in.		392 mm 16 in.	
Wet period	1,004 mm 40 in.		1,057 mm 42 in.		1,018 mm 40 in.		825mm mm 33 in.	
Total per year	1,428 mm 57 in.		1,552 mm 62 in.		1,503 mm 60 in.		1,217 mm 49 in.	

	Longitude	Latitude	Altitude
Tocklai :	94° 12′ E	26° 47′ N	86.6 m (284 ft)
Silcoorie :	92° 48′ E	24° 50′ N	39.6 m (130 ft.)
Nagrakata :	88° 54′ E	26° 54′ N	228.6 m (750 ft.)
Nagri Farm :	88° 12′ E	26° 55′ N	1,158.2 m (3,800 ft.)

Tea in Africa has been found to transpire 85 per cent of that predicted by the Penman estimate, E_o. Should the correction factor turns out to be about 85 per cent for North East Indian tea, then about 16 to 17 inches of water will be transpired at Nagri Farm and Tocklai and 19 to 20 inches at Nagrakata and Silcoorie respectively during the dry months as against an income of 7, 5, 4 and 8 inches of rain at Tocklai, Nagri Farm, Nagrakata and Silcoorie respectively over the same period.

To assess the year to year variability of the Penman Estimate at all the four meteorological sites, an analysis has been made of each of the six years' meteorological data separately, from 1960 to 1965. Results of the analysis are given in Table 5 (b).

Table 5. b: Yearly evaporation in mm for the different meteorological sites

Meteorological Station	Year						L.S.D at 5%
	1960	1961	1962	1963	1964	1965	
Tocklai	1,483	1,444	1,449	1,412	1,374	1,404	110
Silcoorie	1,615	1,627	1,609	1,459	1,527	1,488	120
Nagrakata	1,592	1,503	1,561	1,447	1,502	1,419	108
Nagri Farm	1,257	1,272	1,218	1,190	1,195	1,170	103

Year to year variation has been found to be significant at Silcoorie and Nagrakata ($P<0.05$), whereas no significant variation has been shown at Tocklai and Nagri Farm.

The frequency distribution of evaporation over the year for the four meteorological stations has been found to be normal. Average meteorological conditions were next calculated for ten day units as from the first January each year for all the meteorological sites and for as many years as meteorological measurements are available.

(S. 8.) (b) Radiation measurement :

In the calculation of Penman's estimate of E_{ro}, to give an estimate of short wave radiation income, hours of bright sunshine from a Campbell Stokes Sunshine Recorder have been used instead of taking direct readings of radiation from the Botanical Department solarimeter and actinographs.

As a matter of interest the computed values of total incoming short wave energy in gm cal/cm² per day for each ten day unit for 1965 at Tocklai are compared against actual measured values for the corresponding periods recorded by the actinograph at the Botanical Department. By plotting logarithims of the estimated values (y) against actual measurements of radiation (x) a linear relationship was obtained. The goodness of fit was tested and found to be statistically significant. ($P< 0.001$ and $r^2 = 0.92$. The equation relating these measurements is $\log y = 1.89 + 0.00123\ x$. There is, therefore, a strong possibility of calculating incoming

short wave energy for outstations using the standard sunshine recorder instead of using more costly equipment. An actinograph is now sited at Nagrakata and it will soon be possible to test this hypothesis again under Dooars conditions.

(S. 8.) (c) Rainfall analysis :

The distribution of rainfall between day and night has been analysed from 8 years data at Tocklai. It has been observed that on average during the day (0600 to 1800 hrs. I. S. T.) 703.4 mm (27.7 in.) rain fell per year as against 1,297.2 mm (51. 1 in.) during night (1800 to 0600 hrs.). Also it has been observed that about three quarters of the total rain fell between 2000-0800 hrs. irrespective of the season.

(S. 8.) (d) Routine meteorological observations :

Records of observations for the four different meteorological stations for 1966 are given in the appendix. Meteorological summaries based on the past data recorded at different meteorological stations have been prepared, and these will be issued in the form of a bulletin for the use of Tocklai scientists.

SOIL AND AGRICULTURAL CHEMISTRY

(S. 9.) (a) and (b). Setting up of chemical laboratory and establishing analytical methods and comparative survey:

The reliability of the procedures used for chemical analysis of soils and plant materials have been critically examined and found satisfactory as can be seen from Table 6.

Table 6. Accuracy of the analytical procedures used for the analysis of soil and plant materials. (Data given in the table refer to grass samples made available for this study, and expressed on oven-dry weight basis.)

Inorganic mineral constituents	N%	P%	K%	Mg%	Ca%	Fe p. p.m	Mn p. p.m	Zn p. p.m	Mo p. p.m	Cu p. p.m
Mean value of the samples examined	2.852	0.747	1.913	0.375	0.970	116	59	90	1.747	21
Standard deviation for a single determination	0.034	0.009	0.021	0.018	0.011	3.92	1.03	2.52	0.12	0.48
Coefficient of variation	1.192	1.261	1.119	1.797	1.143	3.39	1.71	2.80	7.06	2.34
Number of samples examined	37	98	76	62	16	32	10	101	71	11

In the above work in each batch of analysis, a standard known sample was included with a view to comparing the recovery data and as a safeguard against gross errors.

SURVEY

The broad conclusions drawn from the data on the chemical status of tea soils at varying period of cropping are given below. These conclusions are based on such soils as have been analysed at the time of writing. Reference has already been made to physical analyses under the section on soil physics above.

1. **Soil acidity status** -Both top and subsoil acidity in tea areas increases with the increased period of cropping due to the leaching of basic nutrients by the carbonic acid in soil water as well as due to the action of sulphate of ammonia. This increase in soil acidity attains maximum intensity during the early years of cropping, i. e., between the period virgin to young tea, which covers about 10 years. Subsequently the rate of increase falls because of the already reduced content of bases, mainly calcium. Thus under the same quantity of leaching agents, different soils may show different orders of increased soil acidity, and this will depend upon the initial base status. Average data for top and subsoils of the different profiles are given in Table 7.

Table 7. Changes in the soil acidity status with the period of cropping

Depth	Age of cropping tea							
	Virgin		10 yr. old tea		20 yr. old tea		40 yr. old tea	
	pH	lime req.	pH	lime req.	pH	lime req.	pH	lime req.
0-30 cm	5.11	1195	4.69	1455	4.72	1715	4.41	1894
30-60 cm	5.16	1386	4.65	1634	4.83	1976	4.59	2111
60-90 cm	5.10	1675	4.72	1874	4.84	2204	4.60	2285

2. **Base exchange capacity and base saturation of soils :** No relationship has been found between the base exchange capacity of soils and the age of cropping. On the other hand base saturation appreciably decreases with the age of cropping as a result of the leaching of basic nutrients. Roughly, threequarters of the replaceable calcium and four-fifths of the replaceable magnesium contents of soils are lost over a 40 year period under cropping.

In this context, loss of soil calcium may be interfering with the efficiency of applied nitrogenous fertiliser, because rate of nitrification may be affected. To test this hypothesis, field trials have been laid out in different tea areas with the co-operation of the Advisory Department.

Low magnesium status may also be limiting crop production. In a rehabilitation trial on old tea soil, magnesium dressings have been given with a view to examine their effects on the growth of replanted tea.

The decrease of the replaceable calcium and magnesium contents of the subsoil layers has been found to be small as compared to the top soil.

Average data for top and subsoils of the different profiles are given in Table 8.

Table 8. *Decrease in percentage base saturation and replaceable calcium and magnesium contents of soils over* **40** *years cropping*

Depth	Virgin Soil			Old Tea Soil		
	Percent base satn.	Calcium kg/ha	Magnesium kg/ha	Percent base satn.	Calcium kg/ha	Magnesium kg/ha
0–30 cm	37	1312	348	10	295	71
30–60 cm	26	962	248	11	467	127
60–90 cm	22	891	286	11	460	101

3. **Nitrogen and organic matter content of soils**—Roughly 9,000 kg/ha of organic matter is lost in 40 years cropping in spite of the addition of a minimum of approximately 3,000 kg/ha of pruning litter and 2,000 kg/ha shade tree litter as dry organic matter annually. Simultaneously about 700 kg/ha nitrogen is lost in spite of the addition of 2,500 kg/ha fertiliser nitrogen.

In general top 30 cm (1 ft.) layer of an old tea site (≥ 40 years) has 0.074 per cent nitrogen content, as against 0.1 per cent nitrogen content of virgin soil. There is reason to believe that fallowing an old tea area with good green crop before replanting, the loss of 700 kg/ha nitrogen as has been observed over a 40 year cropping period can be replaced.

The loss of nitrogen in subsoil layers over the same period has been noted to be half of the observed loss in the top soil, while organic matter in subsoils decreases by almost the same quantity as that of the top soil.

Data on the loss of soil nitrogen and organic matter content over 40 year period of cropping are given in Table. 9.

Table 9. Loss of soil nitrogen and organic matter content with cropping

Depth	Virgin soil			Old tea soil		
	Nitrogen kg/ha	Organic carbon kg/ha	Organic matter kg/ha	Nitrogen kg/ha	Organic carbon kg/ha	Organic matter kg/ha
0-30 cm	3,300	28,600	49,200	2,600	23,500	40,500
30-60 cm	2,535	21,913	37,690	2,079	17,193	29,572
60-90 cm	2,161	18,989	32,660	1,796	14,373	24,722

4. **Phosphate and potash content of soils**— The changes in the available phosphate and potash contents with cropping in top and sub soils do not seem to follow a clear-cut trend. There is an indication that available potash status of soils remain practically unaffected and available phosphate becomes depleted after 40 years of cropping. However, in the first 10 years of cropping over half of the available potash seems to have been used by the crop. This loss gets compensated at the later period of cropping and potash content again rise to the initial value.

Available phosphate content of the subsoil layers has been found to be practically nil, whereas available potash of the subsoil layers has been maintained at a certain level over the entire period of cropping.

The complete absence of available phosphate in the subsoil in spite of their total phosphate contents being 1,000 to 2,000 kg/ha, possibly means that these phosphates are permanently fixed. In the case of top soils, the available pool must have been built up through application of soluble phosphatic fertilisers.

Both total phosphate and potash contents of soils after 40 years of cropping practically remain unchanged from those of virgin soil contents.

Data on the total and available phosphate and potash contents of 3 feet soil profile as affected by cropping are presented in Table 10.

Table 10. Phosphate and potash contents of a 3 feet soil profile as affected by cropping period

Age	Total P_2O_5 (Kg/ha)	Available P_2O_5 (kg/ha)	Total K_2O (kg/ha)	Available K_2O (kg/ha)
Virgin	5,000	100	83,000	1,000
Young	4,000	30	92,500	600
Medium	4,500	15	111,000	700
Old	5,000	20	85,000	800

5. **Loss of soil bases (mainly calcium and magnesium) due to leaching**— It has been observed that the loss of calcium and magnesium due to leaching takes place not only from the available source but also from the reserve source. Roughly 50 per cent of the loss of calcium and 70 percent of the loss of magnesium from a 3 feet soil profile is contributed from the reserve or non-available source. From the present study it is deduced that 45 kg/ha calcium as calcium carbonate equivalent is lost from the available pool for every 112 kg/ha per annum sulphate of ammonia application. This figure of calcium loss closely resembles values reported earlier. But since loss of non-available calcium and the entire question of magnesium have not been taken into consideration in the earlier calculations, it appears that the loss of soil bases has in the past been grossly underestimated.

While taking into consideration loss of magnesium and the loss of reserve calcium, the present study indicates that 168 kg/ha bases as calcium carbonate will be taken out of the soil for every 112 kg/ha sulphate of ammonia application, which is very much higher than the previous estimated loss.

(S. 9.) (c) Effects of management methods on the chemical properties of tea soils :

(i) **Sulphate of ammonia at varying levels and frequency of application**— Seasonal effects on nitrogen removal by plucked shoots have been studied in detail on monthly samples and these effects have been found to be statistically significant ($P < 0.001$) as has been reported last year (see Annual Report 1965, pp.28-31). For this work samples were drawn from the field trial laid out by the Agriculture Department.

(ii) **Large scale trial of shade and manuring (Botany 1 b)** — Soil samples from 3 depths, 0-15, 15-30 and 30-60 cm are analysed for pH, loss on ignition, nitrogen and carbon contents in the first year when shade trees were removed from the five acres of "no shade" plots. No difference has been found between "shade" and "no shade" plots in the first year.

(S. 11.) (a). soil rehabilitation trial :

These trials have been laid out in collaboration with the Agriculture Department. Soil samples have been collected in the first year according to programme.

(S. 11.) (b). **Museum grass plots at Borbhetta (Agriculture Department) :**

To screen the effects of different species of grasses on the soil physical and chemical properties, samples are collected at 2 depths, 0-15 and 15-30 cm, and analysed for pH, loss on ignition, nitrogen and carbon contents. Physical analyses could not be done before the grasses were planted out, because of the absence of a suitable equipment.

(S. 11.) (c). **Soil reclamation trial :**

One trial has been initiated in the Nilpur T. E. (North Bank) in co-operation with the Advisory Department. Two trials in Dooars will be started soon with the arrival of the appropriate chemicals.

(S. 12.) **Analysis for advisory purposes :**

7,600 estimations were carried out on 3,405 soil samples from tea estates for routine advisory purposes, over and above 5,100 estimations carried out under different research projects mentioned above. In addition analyses were made occasionally on mulching materials, manures, leaf and water samples.

BOTANY DEPARTMENT

D. N. Barua—Senior Botanist
W. Hadfield—Plant Physiologist
P. K. Barua—Botanist

STAFF

Mr. P. K. Barua, Botanist, was on annual leave from 1st September to 9th November and retired on 10th November, 1966 after serving the Association for 35 years.

Dr. M. C. Basu, Plant Breeder designate, resigned and left on 22nd February, 1966.

Mr. H. P. Bezbaruah was appointed Plant Breeder from 2nd January 1967.

Mr. W. Hadfield, Plant Physiologist, was on home cum study leave from 15th July to 19th September, during which he visited several research laboratories in the United Kingdom.

Sri T. R. Puzari, Senior Non-technical Assistant, retired on 31st August, 1966.

Sri Sureswar Gogoi B. Sc. and Sri Prafulla Chandra Sarmah B. Sc. were appointed as Junior Scientific Assistants from 1st November, 1966.

RESEARCH AND EXPERIMENT

(B2b) **Trial of biclonal seed :**

Three of the biclonal stocks under trial are showing promise and the parental clones of one of them are likely to be released in the near future for the production of seed on a commercial scale.

More trials and observation plots were laid out in different parts of North East India with all the six stocks.

(B2a) **Tea Breeding :**

With the appointment of a Plant Breeder at Tocklai, it will now be possible to make a proper assessment of the past work on tea breeding carried out at the Station and to plan new lines of investigation for the production of improved strains of tea. Some progress has already been made in cytological examination of the chromosomes in tea, and on induction of polyploidy by mutagenic chemicals and radiations.

(B3c) **Release of vegetative clones :**

Two more vegetative clones, TV 14 and TV 15, have been selected for release in 1967.

TV 14 is a STANDARD clone similar to clone 19/29/13 (TV 1) in size and appearance of the leaf, cup-characters and yield under Borbhetta conditions. The clone can be used for Orthodox as well as for Cut-leaf systems of manufacture.

TV 15 is a YIELD clone similar to clone 3/77 (TV 8) in size and appearance of leaf. The clone is highly pubescent and produces tippy teas. This makes the clone specially suited to Orthodox manufacture.

The first lot of cuttings of these two clones will be available for release in autumn 1967.

(B3g) **Use of growth substances for the propagation of tea cuttings :**

Experiments carried out in the past on the use of growth substances for the rooting of tea cuttings were summarised. Treatment of internode cuttings (i. e. single-leaf cutting with a piece of internode approximately 2.5 cm in length) with six different growth substances (α-NAA, β-NAA, IPA, IAA, IBA, 2, 4-D) and their combinations and the proprietary formulations Seradix and Hortomone A, did not produce significant improvement in strike. However, indolyl-3 butyric acid (IBA) at low concentrations of 25 to 100 ppm improved shoot growth, but the improvement was not observed at the higher concentration of 200 ppm. Treatment of cuttings simultaneously with 200 ppm IBA and a dilute solution of zinc sulphate at a concentration of 200 ppm of zinc counteracted the inhibitory effects of the high concentration of IBA on shoot growth of an experimental clone.

Cuttings treated with IBA rooted earlier, and the root weight even after 7-9 months, was usually higher than the untreated controls. The cuttings with a basal node were more responsive to hormone treatment than the internode cuttings.

When a clone which roots with difficulty was sprayed once a week for three weeks prior to propagation with nutrient solutions containing all the major and minor elements needed for plant growth, the strike of its cuttings improved; but such spraying had no effect on clones which normally rooted well. Poor development of roots on tea cuttings can, therefore, be associated with deficiency or imbalance of some inorganic constituents in the plant. Since easy rooting clones can also suffer from nutritional deficiency or imbalance, the results indicate the necessity of paying special attention to the nutrition of stock bushes maintained for the production of cuttings.

It can be concluded from these experiments that growth substances are not necessary for propagating easy rooting tea clones under commercial conditions. When conditions for propagation are unfavourable and a small number of plants are needed for special purposes, then tea cuttings may justify treatment with low concentrations of IBA.

(B3e) **Criteria for the selection of vegetative clones :**

Information obtained from two large-scale selection schemes undertaken at Borbhetta during 1962-64 led to certain modifications in our recommendations to estates for the selection of vegetative clones (Ann. Rep. 1962, p. 23; 1963, p. 29 and 1964, p. 37). These observations further showed that the rapid, visual estimate of the density of plucking points on bushes was only loosely but significantly correlated with their yields ($r = 0.423$, Predictability Index 9.4%). An intensive search was, therefore, made during 1965-66 for other growth criteria which would give a more reliable estimate of the yielding capacity of tea bushes.

A mature plot of tea planted with 28 different clones was selected at Tocklai for observation. Three average bushes were selected from each clone, making a total of 84 bushes. The bushes were pruned annually and tipped at 20 cm. Counts of the number of plucking points on the bush surface were made in November after which the bushes were pruned and pruning weights recorded.

Among the criteria observed, those which showed significant positive correlation with yield are given in Table 1. The plucking point density of this plot was estimated visually by two trained observers and its relation with yield is also given in the table for comparison.

Table 1. Correlation co-efficients between yield and other growth characters of the tea bush

Growth characters	Correlation co-efficient	$100r^2$	Predictability index
Visual estimate of plucking point density	0.665	44.2	25.3
Absolute number of plucking points obtained from counts	0.811	65.8	41.5
Fresh weight of prunings	0.854	72.9	47.9
Number of pruned sticks	0.699	48.9	28.5
Weight of tippings on 24th April at 10 cm	0.685	46.9	27.2
Number of tipped primaries	0.612	37.4	20.9

The maximum correlation with yield is shown by the fresh weight of prunings, which is even better than the correlation obtained with the actual number of plucking points on the bush surface. Both of these correlation co-efficients are higher than the one obtained from a visual estimate of the density of plucking points. The fresh weight of growth made till the 24th April above a tipping height of 10 cm is also significantly correlated with yield, but the magnitude of the correlation co-efficient is almost the same as the visual score. The correlation between yield and the number of tipped primaries too is significant, but the value of the correlation co-efficient is lower than the one given by the weight of tipped primaries.

The last column of the table shows that accurate prediction of bush yield could be made in 47.9 per cent of the cases by recording the pruning weights, in 41.5 percent of the cases by counting the number of plucking points and only in 25.3 per cent of the cases by eye-judgement of the density of plucking points on the bush surface. This is understandable since estimation of the density of plucking points does not take into account the size of the plucking surface, while bush yield is determined by both. In consideration of this and other factors, it has now been recommended (See T. E. Serial No. 163 filed under B 6) that bushes much smaller than the average of the section where selection is done should be eliminated, even if their plucking point density is high.

While examining very large number of bushes within a short period of time for the selection of vegetative clones, it will not be a practicable proposition to count the plucking points or the pruned sticks on every bush. Pruning weights of the reduced number of bushes retained after quick eye selection in the field could, however, be recorded without much difficulty. Our present recommendation takes into account the correlation observed between tipping weight and yield. Further work is in progress, which might lead to greater refinement of the selection procedure.

(Blg) **Starch in tea roots** :

A plot of mature bushes planted with a clone (19/10/3) of average vigour was selected for this observation. The bushes were pruned in December 1965 and tipped and plucked at a height of 20 cm during 1966. One to three healthy bushes were uprooted on the 15th of every month and all roots between 0.5 to 2.0 cm in girth were used for the observation of starch by the visual starch-iodine method. The roots were cut into pieces of approximately 15 cm length within an hour or so from lifting the bush and a dilute iodine solution was applied to the cut ends. The intensity of the starch-iodine colour developed on the cut surfaces of roots was estimated visually and each colour intensity was given a score ranging from 0 to 10. The colour intensity scores were averaged for the bush or bushes for each sampling occasion.

The intensity of the starch-iodine colour was at a minimum during March. Thereafter it rose gradually reaching the maximum intensity in mid May, after which it remained more or less stationary until mid October when a lower value was obtained. The colour intensity in November, December and until mid January of the following year was nearly the same as the May value. It then dropped sharply reaching the minimum value in March.

The reason for the sharp drop of root starch in October is being investigated. In vigorously growing, young clonal bushes the starch maxima has been observed to shift from mid May to mid June.

Bushes thrown out of plucking in mid September had less starch in the roots in mid December than those rested from mid October. Similarly bushes rested from mid October had less root starch in mid January than bushes rested from mid November. Thus it seems that resting late in the season and for not more than two months is more beneficial than resting for longer periods from September onwards. Bushes not plucked throughout the year, however, had more starch in their roots than bushes plucked throughout or plucked and then rested for 2-3 months towards the end of the plucking season.

(B1e) **Water table and root depth :**

The ill effects of a continuously high water table could be clearly demonstrated on young, sleeve-grown plants. A continuously high water table restricted the development of roots both on Assam and China clones. The effect of a fluctuating water table is under study.

(B1g III) **Day length and winter dormancy in tea :**

Evidence presented below (B1g) would show that the winter dormancy of tea bushes at higher latitudes (Tocklai 26° 17' N) is not caused by a deficit of water and nutrients in the soil. Neither can it be ascribed to low ambient temperature, because similar or even lower temperatures are experienced under high elevation conditions at low latitudes, but the bushes there do not stop flushing although the rate of production of shoots may be slowed down. These considerations have led us to suspect that the shorter days of the winter months are the real cause of dormancy of tea at the higher latitudes. If this hypothesis is correct, then increasing the day length by artificial lighting should break the winter dormancy of tea under Tocklai latitudes.

In the absence of control environment chambers, it has not been possible to put the hypothesis to a proper test. A crude experiment carried out during winter under a combination of fluorescent and ordinary lighting did not succeed in breaking the dormancy of potted tea plants. The experiment will be repeated as soon as equipment becomes available.

(B1a) **Shade × nutrient × clone trial :**

The results of this experimeat have been briefly reported from time to time (Ann. Rep. 1962, pp. 26-28; 1964, pp. 37-38 and 1965, p. 41). The results obtained in 1966 by adding magnesium to the P K mixture were not significantly different from those obtained in 1965 by using P and K alone. Effects of addition of other trace elements like zinc, boron and manganese to the manure mixture will be studied in 1967.

(B1g VII) **Temperature of pruning cuts :**

Measurements taken with thermocouples on bright days in early November, when the air temperature in the open was about 30° C, showed oblique pruning cuts facing the direction of the sun i. e. South and South-West to record temperatures which were 4° to 5° C higher than the ambient temperature. When the cuts were made horizontal to the ground , then the temperature did not rise by more than 2° C above the ambient.

(B1a$_2$) **Large-scale trial of shade and manuring :**

In this experiment manuring treatments were imposed for the first time in 1956 after removal of the *Albizzia odoratissima* shade trees from

the 'no shade' plots in November/December 1965. The three manurial treatments were: (1) 112 kg/ha nitrogen (2) 224 kg/ha nitrogen and (3) N P K mixture consisting of 224 kg N, 45 kg P_2O_5 and 90 kg K_2O per hectare, each treatment being repeated 4 times on both the shaded and unshaded blocks. Nitrogen was applied in the form of ammonium sulphate, P_2O_5 as superphosphate and K_2O as muriate of potash.

Analysis of co-variance of the yield data for the full year on pre-treatment yields of 1965 has shown a significant response to the N P K mixture. Response to the removal of shade and the shade × manure interaction were small and non-significant. Results for the three manurial treatments are briefly presented in Table 2.

Table 2. Dry weight in kg per 100 bushes for 25 plucking rounds (Adjusted on pre-treatment yields)

Treatments	Yields
112 kg N	9.76
224 kg N	10.16
N P K	11.42

L. S. D. at P = 0.05 : 0.998 kg C. V. = 8.68%

It is too early to draw any conclusion from the experiment without taking into account other observations on pest and disease incidence, effects of the treatments on cup characters of made tea and on the soil. Some of these observations will have to be continued over a longer period before any firm conclusion could be drawn.

(Blg) **Leaf temperature :**

Measurements carried out at Tocklai with leaf thermocouples have shown that leaves fully exposed to the sun can reach a temperature above 40°C on bright days in summer. Upto 48°C was recorded in leaves from which wind was excluded artificially. A difference in temperature of 2 to 4 degrees was observed between horizontal and semi-erect leaves, both fully exposed to sun, the former consistently recording a higher temperature than the latter. Shaded leaves rarely rose 2°C above the ambient temperature.

The effect of leaf temperature on photosynthetic rate is of paramount importance in an area where high ambient temperatures are common. A temperature of 40°C is probably well above the optimum for the dark reactions of photosynthesis. Attempts to measure the optimum tempera-

ture for net photosynthesis was not very successful due to an absence of controlled environment equipment. Further attempts will be made as soon as possible.

(B1g) **Growth and environment :**

On the basis of the last few years work on light penetration, leaf pose, environmental factors and leaf temperature, a working hypothesis is advanced on the energy relations of the tea plant. The main features of the *hypothesis* are :

(a) A horizontal leaf type causes heavy self-shading on the foliage below the top hamper.

(b) This self-shading results in a large fraction of the maintenance foliage below the top layer receiving insufficient light for maximum photosynthesis.

(c) Under non-shaded conditions when ambient temperatures are above 30 C. the temperature of fully exposed leaves in the top hamper may be above the optimum for photosynthesis.

(d) Factors (a), (b) and (c) could between them produce a system that on bright days has a large fraction of the maintenance foliage at a light intensity much below that required for maximum photosynthesis.

(e) For tea with a horizontal leaf arrangement *light* shade will result in the temperature of the upper leaves being reduced to just above air temperature, while the visible light intensity reaching the lower leaves will be lowered still further. The small reduction in light intensity incident on the upper leaves might be more than compensated for by the increased photosynthetic efficiency of these leaves because of the lowering of temperature.

(f) Erect leaf types reflect more radiant energy than the horizontal leaves and this results in (i) more light being reflected to lower leaves and (ii) leaf temperatures do not reach the very high levels obtained with horizontal leaves.

(g) The effect of shade on upright leaf types is more pronounced than on horizontal leaf types in the lower part of the bush canopy. This is because in unshaded conditions, the light penetration curves for the two leaf types are very different. The horizontal types show a very steep drop in light penetration below the top-

most layer of maintenance leaves and thereafter a steady decline to the lowest layer of the foliage, whereas the upright types show an exponential drop in light intensity, each layer of foliage reducing light penetration by about 50 per cent. This means that when the surface of an upright leaf type is shaded, a much greater leaf area is subjected to light-limiting conditions than for a horizontal type and photosynthetic efficiency is thereby reduced to a larger extent.

Some evidence in support of the above hypothesis is given in the Annual Reports for 1964, pp. 39-40 and 1965, pp. 11-12. In 1966, an experiment was designed to test it more rigorously.

A corollary to the 7 points above is that upright habit types are more efficient dry matter producers and because of that should have a greater response to the removal of any other limiting factor than the horizontal leaf types. The most obvious limiting factors are soil moisture and nutrients, both of which are easy to supply on an experimental scale. Thus an area planted at Tocklai with two clones, one having horizontal leaves and the other semi-erect leaves, in alternate rows, was divided into two blocks. The area was pruned annually in December January until 1964 but was left unpruned during the 1965 66 cold weather. One block was irrigated at 10 day intervals with approximately 3 cm (1 $\frac{1}{4}$" of water from 7th December 1965 to 2nd June 1966 and the soil moisture was held close to field capacity. An N P K mixture containing a total of 1568 kg N, 392 kg P_2O_5 and 784 kg K_2O per hectare (1400 lb N, 350 lb P_2O_5 and 700 lb K_2O per acre was applied in 14 applications from 7th December to 21st April. The other block was given the same amount of fertiliser mixture in 7 applications from 9th May to 10th July, but was not irrigated. Regular plucking at 7 day intervals throughout the year except during January until late February, when the bushes did not flush, and routine pest and disease control were carried out. At the end of the year the bushes were pruned and the pruning weights recorded. Results are given in Table 3. The yields obtained in 1965 from these two clones growing in the same area are included in the table for comparison. In 1965, the experimental bushes were manured with 112 kg nitrogen per hectare and the area was not irrigated.

Table 3. Effect of irrigation and nutrients on two clones having different leaf types. Fresh weights of pluckings in grams per bush

Clone	1965	1966	
		Without irrigation	With irrigation
X Horizontal leaves	140	213	253
Y Semi-erect leaves	230	562	1060
Per cent increase of 'Y' over 'X'	64	164	311

In the non-irrigated plot, clone Y gave an increase of 164% over clone X compared to 64% in the previous year when the bushes received only 112 kg ha of nitrogen. Irrigation caused a further yield increase of 20% in clone X and 90% in clone Y.

The horizontal leafed clone X showed symptoms of fertiliser damage by the end of July in both the irrigated and unirrigated plots and by October many of the bushes were almost defoliated. The nitrogen content of the maintenance leaves was nearly double that of the control plot and it was suspected that the high concentrations of nutrients in the soil may have plasmolysed root cells. No adverse effect of high nutrient application was noted on the semi-erect clone Y. In view of this, the big difference in the yields of the two clones produced by water and nutrients can be considered to have lost much of its significance. On the other hand, it may be argued that the particular clone X could not utilise such large quantities of nutrients due to the large proportion of its leaves being light-limited and the high concentrations of leaf nitrogen support this view. On this argument the damaging effects of high fertiliser application on clone X merely support the hypothesis, viz. that neither water nor nutrients are likely to give marked increase in yield on plants whose leaf arrangement is such that light in the lower canopy is limiting photosynthesis.

It is, however, stressed that such high rates of nutrient application can be considered only on an experimental basis and are probably much above the optimum for any tea plant. The experiment is being repeated on the same two clones with normal rates of fertiliser application, both in full sun

and under artificial shade. Observations on other clones are also proposed so that the hypothesis could be tested on a wide range of leaf types.

Evidence in support of the postulate (c) is given in Table 4 (also see Ann. Rep. 1959, p. 66, Tables 4 and 5). Two clones 19/29/13 (semi-erect leaf) and 1/7/1 (horizontal leaf) were grown in full sun and under bamboo screens which reduced light intensity to approximately 55-60 per cent of full sunshine. Weights of pluckings in 1960 are recorded in Table 4.

Table 4. Effect of artificial shade on two clones having different leaf types. Fresh weight of plucked shoots in grams per bush

Clone	100% light intensity in full sun	60% light intensity under bamboo - screens	Per cent increase or decrease caused by screens
1/7/1 (Horizontal leaves)	278	295	+5.7
19/29/13 (Semi-erect leaves)	552	403	−27.9

Screens slightly improved the yield of clone 1/7/1 and depressed the yield of clone 19/29/13, which are in conformity with the postulates (e) and (g) of the hypothesis.

The implications of the hypothesis are wide and large scale agricultural trials on irrigation, manuring and shade should bear in mind the foliage pattern of the experimental plants when discussing results of such trials. Even more important is the necessity to realise that for clonal areas optimum field management treatments are likely to vary from clone to clone and from the average treatments now being prescribed for all tea plants.

ADVISORY

Touring—Dr. D. N. Barua visited one estate in Darrang and two estates in Upper Assam. Both Dr. D. N. Barua and Mr. W. Hadfield with two other Tocklai officers visited nine estates in Cachar. Mr. W. Hadfield paid a visit to the Atomic Energy Establishment at Trombay. He also visited Murmuria T. E. on a large number of occasions in connection with the large-scale shade × manuring trial. Dr. D. N. Barua paid a visit to the I. C. A. R. in August.

Identification of plant specimens — Twenty one plant specimens were identified during the year.

Assessment of tasting results — 1120 samples were sent for tasting in connection with the C 5 experiment. Tasting results of 550 samples received from estates were evaluated.

Meetings — Dr. D. N. Barua attended T. R. A. Annual General Meeting in Calcutta in July and two meetings of the Standing Committee for Agricultural Research of the I. C. A. R. in New Delhi during September and December.

Lectures and Conferences — Dr. D. N. Barua gave papers and demonstrations in the three Field Management Courses and two Vegetative Propagation Courses held during the year. He also attended the scientific conference of the UPASI Scientific Department in South India.

Correspondence — Four hundred and thirty seven letters and memoranda were written during the year.

AGRICULTURE DEPARTMENT

K. N. SHARMA — Senior Agriculturist
S. C. BARUA — Agriculturist

The Senior Agriculturist was on Annual leave with effect from 15.6.66 and the Agriculturist was on Annual leave with effect from 4.12.66 to 31. 12. 66.

There has been no change in the Junior Staff during the year.

RESEARCH AND EXPERIMENTS

During 1966, the main subjects for study and experimentation were—Shade, Shade and Manuring, Rehabilitation of Land, Planting and Spacing, N. P. K. Manuring, Nitrogenous Fertilizers, Plucking, Pruning, Cultivation, Irrigation, Weed Control, Green Crops and Clonal Trials. Eighty -six long and short term experiments were conducted at Borbhetta. Assistance, as requested, was given to Advisory Department experiments.

(A. 1) **Shade :**

(a) **Preliminary screening of species**—Altogether 33 species of shade trees including a few already tried ones were screened in these trials. Besides *Albizzia odoratissima*, *A. lebbek* and *A. procera* the following species showed promise as good growers at Borbhetta - *A. julibrissin*, *A. gamblei*, *A. nemu*, *A. zygia*, *Acacia lenticularis*, *Piptadenia falcata*.

The species which produced heavy shade are - (1) *Segame erythrophloeum*, (2) *Peltophorum vogelianum*, (3) *P. dubium* and (4) *A. grandibracteata*.

Out of these, the first three were susceptible to storm damage. Those species which had poor growth are—(1) *Caesalpinea ferrea*, (2) *Entada abyssinica* and (3) *Hymenaea stilbocarpa*.

(b) **Periodic effect** - Bamboo screens were provided for different periods of the year in a trial (B34.1.3) continued from 1958. The treatments produced significant differences ($P = 0.05$) in yield, only in the year 1962 following medium pruning in 1961, showing that the period from March to April may be critical in respect of shade requirement of medium pruned tea in the first year of regeneration as noted in Tocklai Annual Report [1]. It has now been considered necessary to see if the period from November to March is a critical one for shading. Hence in November 1966, the shading period in one treatment (T_3) was changed from July-November to November-February. The treatments as from 1966/67 are as follows :—

T_1— No shade
T_2— Bamboo shade throughout the year
T_3— „ „ from March to November
T_4— „ „ from May to November
T_5— „ „ from November to February

The effect of this change in T_5 has yet to be seen.

(A.2) **Shade and Manuring :**

The mature tea used in a long term factorial experiment comprising N. P. K. combinations (B 5. 1) which was started in 1932 was uprooted in 1959 and replanted in 1961. The original manurial treatments were continued on the same replanted plots but a difference from the old experiment was introduced in that half of the replications were put under *Albizzia odoratissima* shade trees planted in 1961 along with the tea, the other half being unshaded. There were thus created two independent experiments; one under shade and the other under no shade. In each experiment the 16 fertilizer combinations of 4 levels (0, 45, 90 and 135 kg per hectare) of nitrogen, 2 levels each (0 and 22.5 kg ha) of phosphate and potash in the forms of sulphate of ammonia, superphosphate and potassium sulphate respectively, were used.

Analysis of the 1966 crop shows that 22.5 kg K_2O ha gave significant ($P=0.05$) increases, over no potash, of 18 per cent under shade and 8 per cent under no shade.

(A.3) **Rehabilitation of Land for Replanting :**

(a) The problem of rehabilitation for replanting of land that had been under tea was viewed both from the physical and fertility status of the land. It was considered that some grasses may be useful for the purpose. For preliminary screening , 50 species of grasses and cover crops were collected through the courtsey of the I. A. R. I., New Delhi, and also locally. Out of these the following grasses are growing well under Borbhetta condition but their value for rehabilitation purposes has yet to be assessed : *Crysopogon gryllus, Digitaria eriantha, Eragrostis chlorometas, Eragrostis curvula* (Weeping Love grass), *Panicum maximum* (Guinea grass), *Pennisetum purpureum* (Napier grass), Pusa Giant Hybrid Napier, *Tripsacum laxum* (Guatemala grass).

(b) An experiment (B) 11/3) has been started in 1966 to study the effects on rehabilitation of growing Guatemala grass (*Tripsecum laxum*), Thatch grass (*Imberata cylindrica*) and a cover crop (*Mimosa invisa*) for different durations ranging from 0 to 4 years.

(A. 4) **Planting and Spacing :**

(a) Two experiments (B 8/1 and B 8/2) were laid out and planting completed in 1966 to find out the effects on yield of different spacings using different kinds of tea manured with different levels of nitrogen. Spacing ranged from 7000 to 37000 bushes per hectare and nitrogen from 100 to 300 kg/ha.

It has been observed that even with very close spacing within a single hedge, weeding and mulching present no problem. In fact mulching with thatch and jungle in this area showed clear beneficial effects in controlling weeds and conserving soil moisture, ultimately reducing deaths and increasing vigour. Field observation further shows that the plants at close spacings have not yet suffered in vigour compared with those at wider spacings.

Table 1. Average yield of made tea in kg/ha from different spacings (1960-1966)

Spacing	Plants per hectare	Yield
S_1-120 cm × 120 cm	6,944	986
S_2-150 cm × 98 cm	6,802	1103
S_3-150 cm × 75 cm	8,889	1010
S_4-150 cm × 60 cm	11,111	1120
S_5-120 cm × 60 cm	13,889	1168

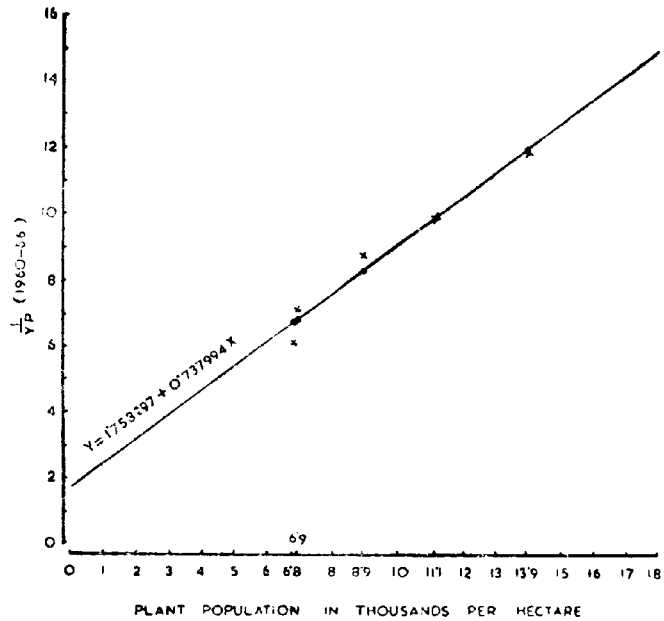
(b) The results of one experiment planted in 1957 (B 104) using five spacings for two *jats* of tea with three levels of nitrogen (90, 135 and 180 kg /ha) indicate, though not significantly so, that closer spacing produced higher yields (Table 1).

Table 2 : Average yield in kg/ha under different nitrogen levels (1960-1966)

Levels of nitrogen in kg N/ha	90	135	180
Yield in kg/ha	1074	1087	1087

Different levels of nitrogen failed to show any significant difference in crop (Table 2). There was no significant interplay of closer spacing with higher doses of nitrogen.

Fig. 1 : Reciprocal of yield per plant ($\frac{1}{YP}$) according to plant population. (yield expressed in kg of made tea)



The yield data of this experiment when transformed into reciprocal of yield plant gave a highly significant linear relationship ($P = 0.001$, 100 $r^2 = 96$) with the number of plants per hectare. This agrees with the earlier work done by Laycock [2 & 3] in this line, where it was predicted that for mature tea, 7000 plants/acre will produce 118.4% of the yield from 2720 plant/acre in Assam, 118.1% in Malawi and 116.0% in Indonesia. The percentage of yield from 17,300 plants/hectare, equivalent to 7000 plants/acre, calculated from the regression equation in figure 1 is 119.1.

(A. 5)- **N. P. K. Manuring :**

All N. P. K. experiments at Borbhetta were reviewed.

(a) **Mature tea.**

Table 3. Average yield of made tea in kg/ha (1960 - 1965)

N. P. K. Mixture	Average yield in kg/ha
T_1—100-0-0	1019
T_2—100-17-0	1050
T_3—100-1-70 (Every 1st and 4th year; other years 100-0-0)	1013
T_4—100-17-0 (Every 2nd and 5th year; other years 100-0-0)	1099
T_5—100-17-0 (Every 3rd and 6th years; other years 100-0-0)	1095
L. S. D. (P=0.05)	65
C. V. %	1.6

(i) As low as 17 kg P_2O_5 per hectare of single superphosphate gave beneficial effects when applied once in 3 years on shaded mature tea (Table 3).

(ii) Application of potash upto 45 kg per hectare proved beneficial on mature shaded tea during the year. The good effect of potash was not consistent in every year.

(b) **Young tea**- In two experiments 4 levels each of P_2O_5 and K_2O (0, 45, 90, 180 kg/ha) and their combinations with a standard overall dose of 90 kg N/ha were tried (Expt. No. B 105 & B 112).

Table 4. Average yield of made tea in kg/ha (1962-1965), according to potash level

Kilogram K_2O per hectare	Yield		Mean
	Expt. B 105	Expt. B 112	
0	1025	1036	1030
45	1060	1108	1084
90	1126	1120	1123
180	1147	1120	1134
L. S. D. at P=0.05	48	62	
C. V. %	12.5	13.6	

(i) Combined analysis of 4 years' data show that in experiment No. B 105 applications of potash were beneficial. Both K_{90} and K_{180} were significantly better than each of K_0 and K_{45}. But K_{180} was not significantly better than K_{90}. In experiment No. B 112 also, potash at all the levels applied was beneficial. But in this experiment there was no further significant increases of yield from potash levels over K_{45} (Table 4).

Table 3. Yield of made tea in kg/ha (1962-1965)

N. P. K. mixtures	Yield		Mean
	Expt. B 105	Expt. B 112	
90-0-0	1043	1078	1060
90-0-90	1103	1130	1116
90-45-0	1064	1130	1097
90-45-90	1134	1126	1130
90-90-90	1131	1130	1130
90-180-180	1164	1175	1170
L. S. D. at P=0.05	89	124	
C. V.%	12.5	13.6	

(Note : The recently revised fertilizer recommendations were based on the results of many past experiments. As the above experiments and others give us more information which will be considered together with the results of the soil survey now in progress, it is more than likely that new recommendations will be issued in not too distant future).

(ii) The application of 90-45-90 produced as good yield as an application of 90-180-180. The yields of some selected combinations are given in Table 5.

(iii) Seven treatment combinations of N. P. K. from both the above experiments were manufactured and tasted by the Tocklai Taster. Mean scores given by the Taster as regards valuation, quality

and strength were not consistent between the experiments. A special statistical sampling technique was employed to minimise errors. In experiment B 112 where N. P. K. mixtures were applied to a *jat* of tea it can be said that 90–90–90 significantly (P = 0.05) increased the valuation and improved the quality in comparison with 90–0–0. In case of clonal tea, 90–0–180 produced inferior quality and less valuation.

Table 6. Average yield of made tea in kg/ha under different treatment combination

Treatments	Average yield of made tea in kg/ha (1962–1966)
T_1–90–180–180 for 8 years (1959–1966)	1508
T_2–90–180–180 for first 4 years (1959–1962) and 90–0–0 for next 4 years (1962–1966)	1533
T_3–90–0–180 only for the first four years (1959–62) and 90–180–180 for the next 4 years (1962–66)	1525
T_4–90–0–180 only for all the 8 years	1546
T_5–90–180–180 and 90–0–180 in alternate years	1575
L. S. D. at p=0.05 C. V%	N. S. 6.3

(iv) In one experiment (B 110) from 1959 to 1966, 90 kg N/ha each year as sulphate of ammonia was applied together with different combination of phosphate and potash. There were no significant differences in crop yield between the treatments (Table 6).

(v) From the above results the following conclusion were drawn :

(1) The old levels of phosphate and potash recommended for young tea i.e. 0–180–180 were unnecessarily high.

(2) Phosphate and potash at doses of 45 kg and 90 kg per hectare respectively, were found economically efficient on young tea.

(3) In mature tea, applications of phosphate as low as 17 kg per hectare once in three years and potash upto 45 kg per hectare were found to be effective, irrespective of whatever nitrogen level was used.

(A. 6) **N. P. K. Manuring of Seed Baris :**

This important project has to be indefinitely left out for want of suitable land. As a result we know very little about seed tree manuring—its proper composition, time and manner of application and still have to rely on the old 12-4-10 mixture of 3 parts sulphate of ammonia, 1 part superphosphate and 1 part sulphate of potash, applied on spread basis, suggested about 25 years back.

(A.7) **Nitrogenous Fertilizers, Other Experiments :**

(a) **Urea as the nitrogen source in N. P. K. mixture for young tea—**

Table 7. Average yield of made tea in kg/ha (1962-1966)

Forms of nitrogen in the mixture kg/ha	Yield	% decrease from S. O. A.
90–180–180, N as sulphate of ammonia	1687	—
90—180—180, N as urea	1640	2.8
L. S. D. at P=0.05	N. S.	
C. V. %	2.3	

Yield figures for 5 consequtive years (B 108,1) proves that urea can replace sulphate of ammonia in N. P. K. mixture for young tea (Table 7). Even if there be an insignificant loss of crop it will be more than made up by the lower cost of urea. Estates making their own mixtures with urea should not allow more than 24 hours to pass between mixing and application, preferably the mixture should be applied immediately after mixing.

(b) **Urea as a nitrogen source for mature tea** —A summary of all urea experiments carried out in the past at Borbhetta and in different estates in Assam South and North Banks, Dooars, Darjeeling and Cachar conducted by the Advisory Department was compiled. It was found in general that :

(i) Urea produced a 5% less crop in comparison with sulphate of ammonia when broadcast annually at 90 kg N/ha.

(ii) Doses higher than 90 kg N/ha did not produce any additional increase in yield under shade. This is similar to the response from sulphate of ammonia).

(iii) Different methods of applying urea other than broadcasting in single dose are under study. Foliar spraying of urea at not more than a 6% solution (w/v) at fortnightly intervals to supplement nitrogen broadcast either as sulphate of ammonia or urea has shown some prospects.

c) **Calcium ammonium nitrate :**

i) First year's (1965) results (B 61.1.1) show that calcium ammonium nitrate was as efficient as sulphate of ammonia when both are applied annually on mature tea at 90 kg N/ha. The long term effects are not yet known.

ii) Leaf samples from plots manured with different forms of nitrogenous fertilizers (B 111.1) were manufactured and tasted by the Tocklai Tasters during 1966. Calcium ammonium nitrate and no manure plots produced significantly higher valuation and better quality and strength than urea manured plots. However there was no significant difference between plots manured with sulphate of ammonia, urea and calcium ammonium nitrate.

d) **Divided doses of sulphate of ammonia :**

i) There was no benefit when nitrogen was applied between 90 kg and 135 kg in two or more divided doses over the single dose (B 113.1). It was however seen from another experiment (B 111.2) that divided doses may have a possibility of increasing yield further when the total nitrogen is more than 135 kg N/ha but the economics await further data.

ii) Tocklai Tasters failed to find any significant difference caused by high doses of sulphate of ammonia when applied in split doses in comparison with single standard doses of nitrogen.

Nature of prunings and mulch as manure (B 31.1.7) :

An experiment was started at Borbheta to study the effects of prunings and that from the yield and vigour of mature tea planted in 1920. First results were obtained in 1966.

Table 8. Yield of made tea and pruning weight in kg/ha according to mulching treatments

Treatments	Yield in kg/ha 1966	% decrease	Pruning weights 12 months after treatments started	% decrease over Tr.1
T_1—Prunings not removed	970	—	10,469	—
T_2—Prunings removed	865	10.5%	8,750	16.4%
T_3– Prunings removed but mulched with thatch and other jungle	916	5.6%	10,208	2.5%
I. S. D. at P=0.05 C. V.%	63 5.3		N. S. 14.2	

All plots received a standard dressing of sulphate of ammonia at 100 kg N/ha. From some plots the prunings were removed and these, in one year, produced 10.5% *less crop* than from equivalent plots where the prunings were left *in situ*. Plots where prunings were removed, but where thatch and other jungle were added as mulch, produced 5.6% *less crop;* but the difference was not significant (table 8). The mulch (1.4% Nitrogen) was added at the rate of 3.5 tonnes per hectare thus supplying 50 kg N/ha.

Prunings contain approximately 66% moisture and 2.5% nitrogen on a dry weight basis. Thus on the plots where prunings were not removed, nitrogen was added at approximately 85 kg per hectare through the prunings. During 1967, mulch has been added to the other plots at the rate of 7 tonnes per hectare to give 100 kg N/ha.

(A.8) **Plucking :**

(a) **Criteria for optimum tipping height**—An average of 5 maintenance leaves was shown by Barua, Barua & Wight [4 & 5] to be necessary between the pruning and tipping heights of a primary shoot to give maximum crop on a long term basis. On the criterion of tipping

over 5 maintenance leaves on the primary, for most kinds of tea grown in Assam under normal condition, the practical tipping height would be 20 cm. But, it may so happen in individual clones that 20 cm tipping height is not necessarily equivalent to 5 maintenance leaves. In a trial (B 33.2A/1), a comparison was made between tipping at a height of 20 cm and tipping over 5 leaves on each primary shoot, using 5 different clones.

Three years' results show that in each of the clones used, 19/29/13 (TV 1), 20/23/1 (TV 2), 1/7/1 (TV 3), 3/77 (TV 8) and 16/8/23, five maintenance leaves on individual shoots of the bushes are equivalent to a flat optimum tipping height of 20 cm in terms of crop yield.

(b) **Severity of plucking :**

(i) Data for 30 years (1935-1964) of a long term experiment (B 20) laid out on a section of Rajghar tea showed that tipping at 10 cm above pruning height and then leaving a leaf at the end of second flush is as good as, if not better, than tipping at 20 cm (Table 9)

Table 9. *Average yield of made tea in kg/ha from different tipping measures (1935–1964)*

Tipping Measures	30 years' average yield in kg/ha
10 cm	1149.8
15 cm	1153.5
20 cm	1148.9
10 cm + 1 leaf from July	1170.5
15 cm + 1 leaf from July	1089.7
20 cm + 1 leaf from July	1094.2

Tipping low (10 cm) in the early monsoon and then raising the table by one leaf also tends to increase second flush crop, without losing total crop.

(ii) Leaf samples from the different treatments were manufactured and tasted by the Tocklai Taster. There were no significant differences in valuation and quality of teas between the different tipping heights of 10, 15 and 20 cm above the pruning cut.

(A. 9) **Pruning :**

(a) **Pruning of Young tea**—The standard method of pruning young tea recommended by Tocklai was modified in one of the treatments in experiment No. B 106 I started in November 1958. In this treatment (T_5), the bushes were left unpruned and unplucked for the first year, in contrast with Tocklai's standard method where in the first year they are plucked at 30 cm, pruned at 45 cm and then centered at 22.5 cm (T_1).

Table 10. Yield of made tea in ½ lbs. 1959-1965

Treatments	1960	1961	1962	1963	1964	1965	Mean	% increase over mean T_1
T_1 —Tocklai Standard Method	257	599	1672	1220	2033	2033	1302	---
T_5— Modified Method	262	789	1767	1399	2090	2128	1406	8.0
L. S. D. at P = 0.05	51	91	120	108	N. S.	N.S.	N. S.	
C. V. %	12.8	7.7	5.4	5.2	5.2	3.8	1.6	

Total yields from 1960 to 1965 (Table 10) show that the modified method gave about 8 per cent increase in crop. In the 2nd (1960) and 4th (1963) years there were significant increases of annual crop from this modified method over the standard method.

(b) **Pruning Vs. deep skiff in interplay with manures :**

The object of the experiment (B 2A. 1 5) was to study the effect of sulphate of ammonia alone and N. P. K. mixtures on pruned and deep skiffed tea following medium pruning. Kherijan 7/2 was planted in 1940

and were medium pruned in December 1964 at 67 cm from the ground. It was plucked during 1965 at 25 cm from the pruned level and 90–180–180 mixture was applied to all plots. In December 1965 the following pruning treatments were given and the manures were applied in March 1966. The treatments were :

T_1— Pruned 2.5 cm above the medium pruning cut. Tipped 20 cm above prune. Manure : 90-0-0 kg/ha as sulphate of ammonia.

T_2— Pruned 2.5 cm above medium pruning cut. Tipped 20 cm above prune. Manure : 90-22-30 kg/ha.

T_3— Deep skiffed at 10 cm above medium pruning cut. Tipped 10 cm above skiff. Manure : 90-0-0 kg/ha as sulphate of ammonia.

T_4— Deep skiffed at 10 cm above, medium pruning cut. Tipped 10 cm above skiff. Manure : 90-22-30 kg/ha.

Table 11. Yield of made tea in kg/ha

Prune Deep Skiff / Manure	Prune	Deep-Skiff	Mean	% increase
90-0-0	792	986	889	—
90-22-30	777	1115	946	6.4
Mean	784	1050		
% increase	—	33.9		
	For Pr/D. S.	For manure	For combinations	For interaction
L. S. D. P = 0.05	55	55	77	55
C. V. %	8.8	8.8	8.8	

Results :

(i) **Prune vs. deep skiff**— Deep skiffing significantly ($P>0.01$) produced 33.9 per cent crop than pruning.

(ii) **N. P. K. mixture vs. nitrogen**—99-22-30 significantly produced 6.4 per cent more crop than 90-0-0.

(iii) **Effect of interplay of pruning types and manures**-Deep skiffed tea manured with a mixture of 90-22-30 significantly produced the highest yield and 13% higher crop than deep skiffing and manuring with 90-0-0. There was no significant difference between 90-0-0 and 90-22-30 when applied to pruned tea.

(iv) **Periodic crop distribution of made tea** This experiment confirmed the previous findings that deep skiffed tea gives a higher percentage of second flush crop and this is further increased by the application of 90-22-30.

It can be summarised that the application of comparatively low doses of phosphate and potash on top of the standard dose of nitrogen proved beneficial to deep skiffed tea after medium pruning even when high doses of phosphate and potash had been applied in the previous year.

(c) **Chemical defoliants :**

(i) **Gramoxone** at 3.0 l/ha and 4.5 l/ha was sprayed on mature tea to see if it can replace hand defoliation, when the latter is necessary. The effects of these two chemical treatments were compared with hand defoliation and no defoliation.

The chemical at both rates, did not defoliate the bushes completely and there was much die back of shoots. Lichen and mosses on the frames of bushes were controlled by gramoxone spray. Yield of crop in the year following defoliation was significantly ($P=0.05$) reduced by 12.8 and 15.1 per cent due to gramoxone sprayed at 3.0 and 4.5 l/ha, respectively.

(ii) **Aretit** was sprayed at the rate of 5 to 15 kg/ha on mature tea as defoliant. There was 60 per cent defoliation (on visual scoring) with no appreciable amount of die back. Further studies are in progress.

(A. 10) **Cultivation and Weed Control :**

All the herbicides tried up to date at Borbhetta have been tabulated to show their effects on different weeds and grasses are given in Tables 12 to 14.*

Table 12. Effective doses of herbicides in different areas

Site	Herbicides	Pre or Post Weed emergence	Number of applications	* Quantity per hectare	Time of application	** Type of Weed controlled	Remarks
1. **Nurseries :** (a) V. P. Bed	Simazine	Pre	One	4 to 6 kg	12 to 14 days before planting	Bw. & Sgr.	
(b) Alkathene Tube	Simazine	Pre	One	3 – 4 kg	-do-	Bw. & Sgr.	
(c) Seed Bed	Simazine	Pre	1st	4 kg	June	Bw. & Sgr.	
			2nd	2 kg	September		
2. **Young Tea :**	Simazine	Pre	1st	4–6 kg	March	Bw. & Sgr.	
			2nd	2–4 kg	July/August		
	Atrazine	Pre	1st	3–4 kg	March	Bw. & Sgr.	
			2nd	2–3 kg	July/August		
	Dalapon	Post	1st	3–4 kg	April	Gr.	Spray on 10 to 15 cm of weed growth, should not be applied before 6–9 months of transplanting.
			2nd	3 kg	July/August		
	Gramoxone	Post	1st	1.5 lit	Subsequent spray at 3 to 4 weeks interval	Bw. & Gr.	Avoid drifting of spray on tea.
			2nd	1 lit.			
			3rd	1 lit.			
			4th	1/2 lit.			
	Simazine & Amitrole	Pre Post		3 kg 3 lit.		Bw. & Gr.	Under further detailed study
	Diuron + Amitrole	Post Post		3 kg 3 lit		Bw. & Gr.	-do-
	Afalon	Post		4 kg		Bw. & Sgr.	-do-

Table 12. (Contd.)

Site	Herbicides	Pre or Post Weed emergence	Number of applications	* Quantity per hectare	Time of application	** Type of Weed controlled	Remarks
3. **Mature Tea :**	Same as for young tea						
4. **Green Crops:**	Most of the green crops are susceptible to all herbicides mentioned. On treated area green crop should be sown 4 to 6 months after spraying.						
5. **Thatch Bari :**	2, 4-D	Post	2nd and When necessary	2-3 kg		Bw.	
	MCPA	Post	-do-	2 kg		Bw.	
6. **Drains Roadsides and non Tea areas :**	2,4-D	Post	As and when necessary	3 kg		Bw.	
	2, 4-D	Post	-do-	2 kg		Bw.	
	2, 4-D + 2, 4, 5-T	Post	-do-	1 : 1 at 2 to 2½ kg in Diesel oil		Bw.	
	Gramoxone	Post	1st	2 lit		Bw. & Gr.	
			2nd	1½ lit			
			3rd	1 lit.			
	Dalapon	Post		6kg		Gr.	
	Dalapon + Gramoxone	Post		1 kg + 1½ lit		Gr. & Bw	
7. **Killing Trees :**	2,4,5-T		Thrice at monthly interval	3% v/v with water	Growing season	Trees	10 ml of soln. in 10 cm girth
				1% v/v with Diesel oil	Dormant season		
	2, 4-D + 2, 4, 5—T		-do-	2 : 1 ratio 3% v/v with Diesel oil		Trees	Apply as paint in exposed wood of ring barked trees

* Dilution : 500 litres of water/ha when using mini-knapsack sprayer. In non tea areas with Fontan (No. 40 jet) 250 litres water/ha will be required.

** Bw. Broadleaf weed. Gr. = Grasses. Sgr. = Shallow rooted grasses

Table 13 (a). Herbicides which produce phyto-toxic effects if used wrongly (ground application)

S = Severe, M = Mild, VM = Very mild

Herbicides	Phyto-toxic rate/ha starts at	Nursery	
		Seed	Cutting
Afalon	4.0 kg	VM	VM
Amitrole	2.4 kg	S	S
Atlavar	0.5 kg	S	S
Atratone	6.0 kg	M	M
Atrazine	1.0 kg	M	M
Casoron	2.0 kg	S	S
C. M. P. P.	1.0 kg	M	M
Dalapon	2.0 kg	S	S
Diuron	4.0 kg	M	M
Gramoxone	0.5 lit	S	S
Maleic hydrazide	10.0 lit	S	S
Prefix	4.0 kg	VM	VM
Prometone	2.0 kg	S	S
Propazine	6.0 kg	VM	VM
Weedone LV 4	2.5 kg	S	S
2, 4-D	1.0 kg	M	M

Table 13 (b). Herbicides which have little or no phyto-toxic effects (ground application) on young and mature tea

Herbicides	Rates per hectare tested upto
Afalon	6 kg
Amitrole	4 lit
Dalapon	4 kg
Dicryl	6 lit
Diuron	4 kg
Eptam	12 lit
FW 925	10 lit
Gramoxone	5 lit
Nia	20 lit
Prefix	4 kg
Propazine	6 kg
Simazine	27 kg
Solan	20 lit
Stam F	10 lit

Weeds		Chemicals																					
Botanical name	Local name	Afalan (Linuron)	Altavar	Atratone (Primatal B)	Atrazine (Gesaprim)	Casoron	CMPP (Iso coronox)	Dictyl	Diuron (Karmex)	Dalapon	Eptam (E P T C)	Gramoxone (Paraqua')	Nata	Nia (Swep)	Prefix	Prometone	Propazine (Gesamil)	Simazine	Solan	Weedazole (Amitrole)	Weedone (WDNEL)	2, 4—D	2, 4, 5—T
Monocotyledonous		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. Chrysopogon aciculatus	Bongooti	S			S				S	S			S				S	S					
2. Arundinella bengalensis	Topasoli	S	S			S				S		S											
3. Cynodon dactylon	Dubori bon			S	S				S	S						S	S	S				I	S
4. Cyperus sps.	Kaina bon	S						I		S		S										I	S
5. Colocasia antiquorum	Kachu											S				I				S	S	S	S
6. Eragrostis unioloides	Cheerabon	S								S												I	S
7. Eleusine indca	Babosa bon				S					S													I
8. Imperata cylindrica	Uloo-kher	S	S							S		S	S									I	S
9. Oxalis acetosella	Bortengsi tenga			S	S				S			S				S	I	I					S
10. Oxalis corniculta	Soroo tengsi tenga			S	S				S			S				S	I	I					I
11. Paspalum conjugatum	Banhpatia bon	S	S	S	S	S		S	S		S	S	S	S		I	S	S	I			S	S
12. Saccharum spontaneum	Konhua bon		S					I		S		S	S	I					I			I	I
13. Setaria palmifolia	Naga-pat			I					I	I		S	S						I			S	S

Table 14. (*Contd.*)

Botanical name	Local name																						
Dicotyledenous Weeds :																							
1. Agratum conyzoides	Gondhoa bon	S	S	S	S	S	S	S	S	I		S		S	S		S	S	I	S	S	S	S
2. Borreria hispida	Bagrakata (big)	S	S	S	S	S	S	S	S		I	S		S	S	S	S	S	S	S	S	S	S
3. Borreria ocymoides	Bagrakata (small)	S	S	S	S	S	S	S	S		I	S		S	S	S	S	S	I	S	S	S	S
4. Clerodendron infortunatum	Dhopat tita		S		I	S	S		S	I		S			S		I	I		S	S	S	S
5. Commelina benghalensis	Konashimola			S	S		S		S	I		S		S	S		S	S	I	S		S	S
6. Eupatorium odoratum	Sam-salakh		S	S	S	S	S		S			S			S	S	S	S		S	S	S	S
7. Erechthitas vaberianaefolia	Bonkopah	S	S	S	S	S	S		S		I	S			S		S	S	I	S		S	S
8. Ficus sps.	Dimoru				I				I			S			I		I	I		I		S	
9. Hydrocotyle asiatica	Bormanimuni				S	S		S	S			S			S		S	S		S		S	
10. Hydrocotyle rotundifolia	Saroomani-muni				S	S		S	S			S			S	S	S	S		S		S	
11. Hedyotis lineata	Kachidoria		S		S	S	S		S						S		S	S				S	S
12. Ipomea cymosa	Kolia-lata			S			S	I	I						I							S	S
13. Leucas lenata	Doron bon			I	I				S						S		I	I				S	
14. Melastoma malabathricum	Phutooka	S	S	S	S			S	S			S			S	S	S	S		I		S	S
15. Scoparia dulcis	Jharoo bon	S	I	S	S	S	S	S	S		I			S	S		S	S		S	S		
16. Urena lobata	Borsonborial	S			S		S		S			S			S	S	S	S		I		S	S
17. Mikania micrantha		S		S	S		S		S			S			S	S	S	S				S	S

(A. 11) **Irrigation :**

Three trials were started to study-

(a) The effects of replenishment of soil moisture lost through evaporation and transpiration.

(b) Whether tea can be plucked all the year round with modification of the time and method of pruning aided by irrigation in droughty months.

The data is being collected in co-operation with Soils Department. Preliminary results show that bushes remained dormant under both irrigated and non-irrigated unpruned plots from January to the end of February. During this period no appreciable amounts of two and a bud shoots could be plucked from middle of January to end of February.

(A. 12) **Green Crop :**

Mimosa invisa when planted inter-row with a tall grass like *Tripsacum laxum* (Guatemala) in fallow land grows well. But it covers completely short grasses such as *Imperata cylindrica* (thatch) and is particularly successful in controlling weeds and short grasses.

(A. 13) **Clonal Work :**

(a) **Clonal trial**—An area (B. 40) has been planted out with Tocklai Release Clones and a few more prospective Releases together with some *jats* for future study of their responses to nutrient and management operations.

Multiplication plots have been established with the Releases and future Releases of the Tocklai vegetative and generative clones to supply cuttings and plants to the Industry when required.

(b) **Packing and storing of cuttings for transport**—A short term trial, repeated at Borbhetta and Nagrakata, in cooperation with the West Bengal Advisory Department proved that fresh cuttings or shoots packed in sealed polythelene tubes can be successfully stored for at least 24 hours before planting. The survival of such cuttings is equal to that of stored pretreated or immediately planted fresh cuttings. This confirms the earlier findings as reported in Tocklai Annual Report [6].

ADVISORY

Touring – The Senior Agriculturist along with three other officers of the Station visited 9 estates in Cachar during April, 1966.

Trainees- Seven employees of T. R. A. Member estates, one employee of a T. R. A. Non- Member estate and one employee of the Tea Board joined the One Year Training Course on 2. 1. 66 and completed their training on 31. 12. 66.

Eleven bonafide and prospective employees of T. R. A. Member estates joined our Short Term Training on Vegetative Propagation and out of them seven completed their training during the year. In addition to these, two who joined this training during 1965, also completed their training during the year.

Lectures and Meetings- The Senior Agriculturist and the Agriculturist lectured on the following subjects during the year :-

(1) (a) "Common Weeds in Tea" in the 'Use of Agricultural Chemicals Courses'- by the Senior Agriculturist

(b) "Chemical Control of Weeds"-by the Senior Agriculturist

(c) "Management of Clones"-by the Senior Agriculturist in 'Vegetative Propagation Courses'.

(d) "Establishment of Young Tea" in the 'Field Management Courses' by the Senior Agriculturist.

(2) "Chemical Manures in Tea" in the 'Use of Agricultural Chemicals Courses'- by the Agriculturist.

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[1] Annual Report. (1962). T. R. A., Cinnamara, India. Page 36.

[2] Laycock, D. H. (1961). 'Yield and spacing of tea'. *Trop. Agriculture, Trin.* Vol. **38**, 3. Pages 195-204.

[3] Laycock, D. H. (1967). 'The number of seedling plants per acre and the yield of tea.' *Two & A Bud.* Cinnamara, India. Vol. **14**, 1. Pages 16-19.

[4] Barua, D. N. (1960). 'Plucking in relation to prunings : Some physiological principles.' *Two & A Bud.* Cinnamara, India. Vol. **7**, 1. Pages 3-8.

[5] Barua, D. N., Wight, W. (1959). 'Shoot production in cultivated tea (*Camelia sinensis L.*) : I- Apical activity and radial growth.' *Phytomorphology.* Vol. **9**, 3. Pages 242-250.

[6] Annual Report. (1966). T. R. A., Cinnamara, India, Pages 39 & 57.

Labour– The average daily attendance of labour during the year compared with that of last five years was as follows :-

1961	...	337.18
1962	...	299.29
1963	...	253.31
1964	...	229.00*
1965	...	250.22
1966	...	247.57

(lower attendance due to a strike)

Crop– The total yield of green leaf during the year compared with that of last five years was as follows :—

Year		Yield
1961	...	1,31,782 kg
1962	...	1,24,788 kg
1963	...	1,23,483 kg
1964	...	1,26,671 kg
1965	...	1,32,131 kg
1966	...	1,34,730 kg

Out of the 1966 crop, 1,16,206 kg of green leaf was sold to the Jorehaut Tea Company, Ltd. General plucking was stopped on 23. 11. 66.

Vegetative Propagation– During the year a total of 62,700 cuttings were supplied to T. R. A. Member Gardens and our Advisory Departments, and as a special case 100 pre-treated cuttings were supplied to the Tea Board. Besides these, 1143 clonal plants were also supplied to some T. R. A. Member Gardens.

Eighty two rooted cuttings of 4 different shade tree species were distributed to some T. R. A. Member Gardens during the year.

Buildings– Three pucca Labour Quarters and four-pairs latrines were constructed during the year.

Land– Borbhetta Field Experimental Estate has been used for about 50 years for all kinds of experiments on fertilizers, application of lime and sulphur (in heavy doses), different methods and intensities of soil stirring, shade and no shade etc. and as a result many areas at Borbhetta have become unreliable for future experimentation. There is no new land left at Borbhetta; and therefore obtaining an area of virgin land to conduct new field experiments has become an urgent necessity.

ENTOMOLOGY DEPARTMENT

B. BANERJEE—Entomologist

STAFF

There has been no change in the staff position. The Entomologist was on leave and duty from 1. 5. 66 to 24. 6.66 and from 12. 10. 66 to 4. 11. 66. During these periods Mr. N. S. Sengupta, Asstt. Entomologist, was in charge of the department.

RESEARCH AND EXPERIMENT

(N 7) **Red spider** (*Oligonychus coffeae* **Nietner**) **on tea :**

(A) **Population variation** — Seasonal population variation under following conditions was investigated during the period mentioned against each.

(1) Bushes in well drained and poorly drained areas (May - December)
(2) Bushes in skiffed and pruned areas (April-December).

Each month 1000 bushes from each treatment were examined. A population index, based on ranking of the groups of mites, was used to assess the degree of infestation.

Except in October and November, significantly high ($P \leqslant 0.05$) populations were noticed in all months on bushes in poorly drained area. The reasons for the deviation during October-November are not clear; a contributory cause may be that during this period the mites breed slowly. This study, however, supports the hypothesis that healthy bushes i.e. those growing in well drained areas, are less prone to mite attack than weaker ones.

There was no significant difference in the populations of Red spider on pruned and skiffed teas, except during May, November and December, when skiffed tea had significantly high ($P \leqslant 0.05$) mite populations. This happened because skiffed tea in general had more foliage than pruned tea.

Assam *jats* had in general less Red spider than the China *jats*.

(B) **Clonal susceptibility** — Studies on the mite susceptibilities of different Tocklai release clones did not indicate any specific trend of mite infestation. Clone TV 9 (106/1) had however least Red spider and was significantly ($P \leqslant 0.05$) less susceptible to the mite than Clones TV 4 (20/6) and TV 6 (61/4), but not to other clones.

(C) **Effect of light**— Red spiders are photopositive and move towards the light of highest intensity, when exposed to two lights of unequal intensities provided the temperature does not exceed 35 C. They infest China *jats* more than Assam *jats* because in the former light penetrates deep into the bushes and their phyllotaxy precludes a high

rise in leaf temperature. In the field, they lay the largest numbers of eggs about dawn and dusk when a change in light intensity takes place. In the laboratory, Red spiders can be induced to lay eggs any time during a 24-hour cycle, simply by changing from light to dark or *vice versa.*

(D) **Intra-bush variation in distribution** — An eight month study (May to December) on the distribution of Red spiders in the upper, middle and lower zones of mature tea bushes (over 20 years old) confirms last year's finding, that mites colonise the middle zones of the bushes more than the other two zones. There was however not always a significant difference between the populations maintained in the middle and lower zones, although each of these poopulations differed significantly from the one in the upper zone. Population was always least in the upper zone. Although Red spiders are photopositive, they are least in the upper zone of the bushes where sunlight is most abundant, because high leaf temperatures (mostly above 35° C) in the upper zone inhibit the activities of the mites. In the middle zone leaf temperatures are lower and a favourable amount of sunlight is also available.

(E) **Aggregation** — Although Red spiders are known to be distributed in patches, investigations revealed that on the basis of their locations, these patches can have six different patterns (Fig. 1). These patterns are correlated with the number of mites present on the leaves.

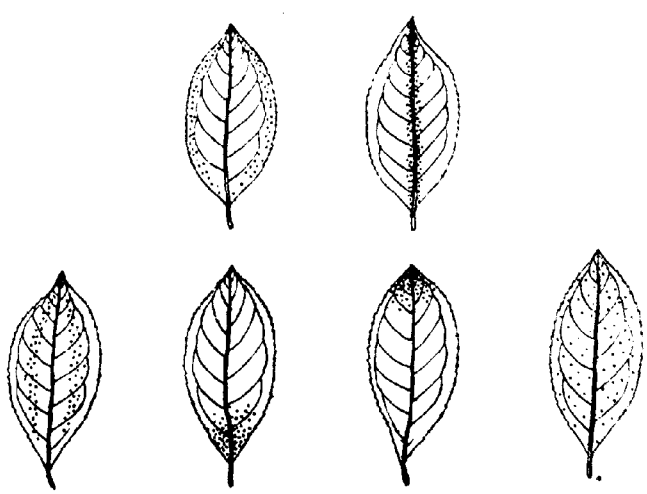


Fig. 1. Patterns of Red spider patches

(F) **Toxicological studies** — Experiments were carried out using 0.1% and 0.05% of Dessin 50% W. P. (2-sec-butyl 1-4, 6-dinitrophenyl isopropyl carbonate) along with 0.037% Kelthane which is a standard acaricide. 0.1% Dessin was equitoxic to Kelthane 0.037% (Fig. 2).

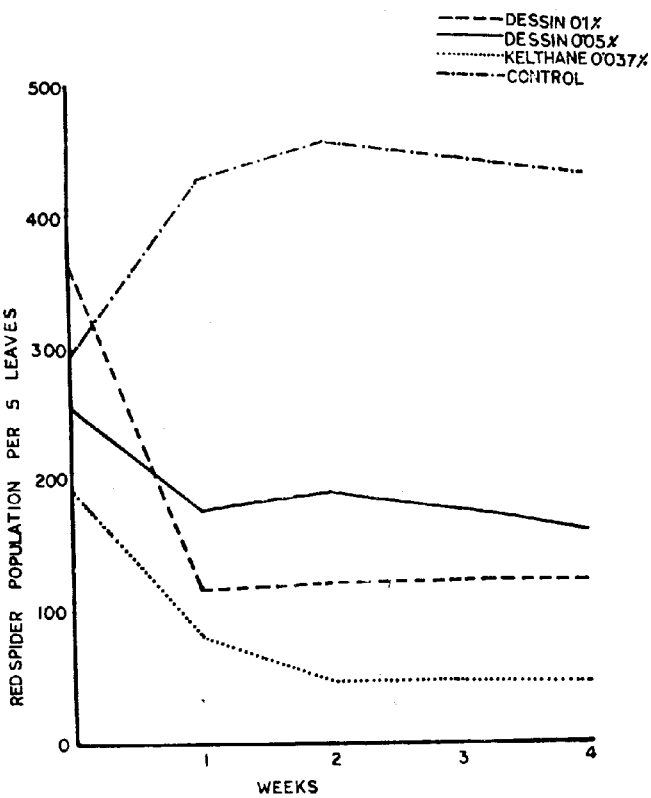


Fig. 2. Effect of Dessin and Kelthane on Red spider

(N 7) **Pink mite,** *Acaphylla theae* **(Watt) Keifer :**

Toxicological studies with 0.0025%, 0.005%, 0.01% and 0.02% concentrations of Fenoflurazole (5,6-Dichloro-1-phenoxycarbonyl-2-trifluromethylbenzimidiazole) show that a 100% mortality under laboratory conditions can be obtained only with 0.02% concentration of the acaricide.

(N7) **Scarlet mite** (*Brevipalus phoenicis* **Geijskes**) :

Some studies on the effect of light on the behaviour of this mite have also been made. Unlike Red spider, this mite is photonegative and moves away from the source of light. This is most probably one of the reasons for its preference for the undersurfaces of leaves.

(N 7) **Comparative ecology of tea mites**

Ecology of Red spider, Pink mite, Scarlet mite and Purple mite under the usual field management practices of estates are being studied at Murmuria T. E. This experiment was started in March 1966. Specieswise weekly records of mite populations are being maintained from areas having shade or no shade, each with different dosages of manures. The object is to find out whether or not these factors have any significant influence on the regulation of mite populations.

Preliminary data covering all mites indicates that although the shaded areas have numerically less mite populations than unshaded areas, shade does not cause any apparent difference so far as mite damage to tea is concerned.

Irrespective of shade treatments, plots manured with NPK at 225-45-90 kg/ha have less Red spiders and Scarlet mites than those manured with only 112 kg N/ha.

(N8) **Tea aphis,** *Toxoptera aurantii* **Boyer**

(A) **Life history** — Laboratory studies indicate the freshly hatched nymphs moult four times before becoming adults. The duration of the life cycle varies in different seasons, from 5 days in August-September to 10 days in December.

Although both alate and de-alate females were seen in the field in different numbers all the year round, males have not yet been found.

(B) **Predators and parasites** —The following predators and parasites play important roles in regulating the population of this aphis in the field.

(i) *Syrphus balteatus* De Geer (Diptera : Syrphidae)
(ii) *S. serarius* Wied (Diptera : Syrphidae)
(iii) An unidentified Neuropterous species
(iv) *Cryptagonus bimaculata* Kapur (Coleoptera : Coccinellidae)

(v) *Scymnus* sp. (Coleoptera : Coccinellidae)
(vi) *Verenia vincta* Gosham (Coleoptera : Coccinellidae)
(vii) *Aphelinus* sp. (Hymenoptera : Aphelinidae)
(viii) *Trioxys* sp. (Hymenoptera : Braconidae)

Of these (vii) and (viii) are parasites and the rest predators.

(C) **Population studies** — Assessments of aphis populations were made at fortnightly intervals during the year, except during November-December, because the bushes were then pruned. At each observation, the numbers of insects on eight shoots drawn at random from each of the outer, middle and inner zones of 10 bushes were counted. The data is presented in Fig. 3. The highest number of aphids was recorded in February. Following this, there was a gradual decline until July, when the population was at its lowest. An increase was noticed in August, but by September-October, it had died down. The position of the population in November-December will be studied next year (in 1967) to complete the picture of the annual population cycle.

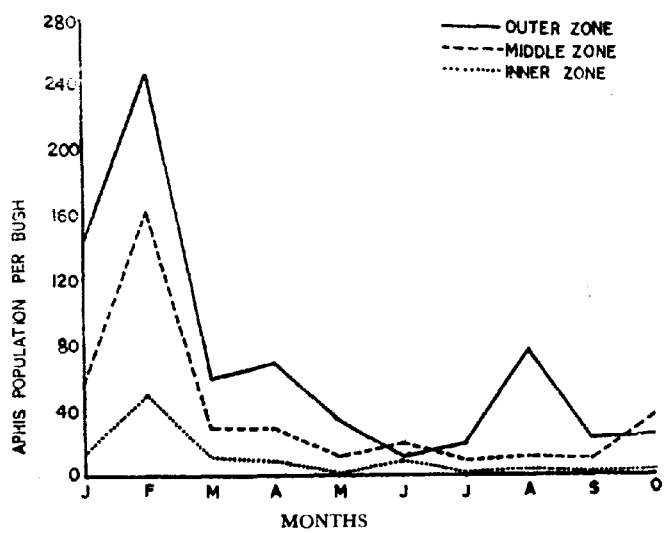


Fig. 3. Seasonal variation in the Aphis population in outer, middle and inner zones of tea bushes.

(D) Intra-bush variation — In all months, the highest numbers of aphids were found in the outer zone (periphery) and least in the inner zones (Fig. 3).

(E) **Susceptibilities of young and mature bushes** — A comparative study of the degree of infestation of young and mature tea was made from February to October. The assessment was made from the monthly counts of infested and uninfested shoots from 25 bushes. The data presented in Fig. 4 shows that except in February and October, young tea was always more prone to aphis infestation than mature tea.

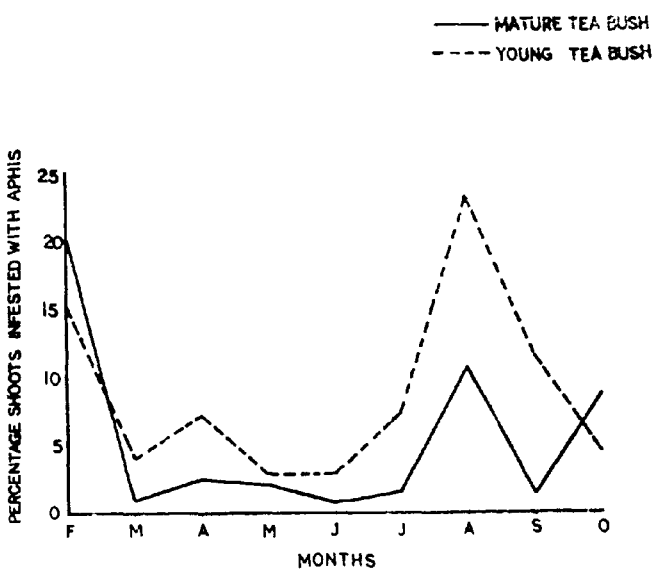


Fig. 4. Seasonal variation in the Aphis population in young and mature tea bushes.

(N 8) **Shade tree pests :**

(A) **Pest distribution** —A survey of the distribution and abundance of the pests shows that Membracids and Green caterpillars on *Albizzia odoratissima*, *Agrilus beesoni* on *Albizzia lucida* and *A. chinensis*, and an Eumolpid beetle on *Albizzia chinensis* were dominant throughout the year.

(B) **Root borers of nursery and young shade trees**, *Sternocera aurosignata* Th.—Laboratory bred adults laid eggs in September/October. These eggs hatched in January-February. The larval stage lasted till May-June, when pupation began. Adults emerged in August-September. The approximate durations of egg, larval and pupal periods were 120, 130 and 90 days respectively.

(N8) **Pests of green crops :**

(A) **Scale insect** — Asterolecanium sp. has recently been found to infest *Tephrosia candida*. This scale causes severe damage to its host plant by sucking the nutrient sap out of the growing shoots. Consequently the plants become stunted.

Field trials were carried out using single application of Malathion 50% E. C. (0.1%), Rogor 40 E. C. (0.04%) and Lime sulphur (2.5% of the formulation). Malathion and Rogor gave good control of the early instars and were equitoxic. None of them was, however, very effective against adults. Two applications of Malathion and Rogor were fairly satisfactory against adults.

Detailed studies on biology are in hand.

(B) **Flea beetle** (*Longitarsus* sp.): This beetle causes severe damage to *Crotalaria anagyroides* and *C. grahamiana*.

Eggs are orange coloured, bean shaped, 0.54 mm in length and 0.23 mm in width at the broadest point. Incubation period is 10 days.

Freshly hatched larvae are pale yellow with brown heads. They are 0.90 mm in length and 0.16 mm in width.

These insects can be seen all the year round, the largest numbers appearing during May-June.

Beetles maintained in constant darkness in the laboratory consumed almost double the amount of food eaten by those under constant light.

(N8) **Soil Biology :**

Termites in tea ecosystem — In certain pockets of the tea growing areas termites are abundant. So far 10 different species belonging to four families have been recorded. The new records include *Neotermes buxensis* Ronwall and Sen Sharma (Kalotermitidae), *Coptotermes heimi* (Wasmann) (Rhinotermitidae), *Microcerotermes* sp., *Microcerotermes pakistanicus* Ahmed, *Odontotermes feae* Wasmann, *Microtermes* sp., and *Capritermes* sp. (Termitidae). Of all the termite families, Termitidae occupies the dominant position both in the number of species represented and in the number of individuals of each species.

Feeding activities of these termites can be divided broadly into three groups. (1) Those damaging the living parts of the plant body. These termites have specialized in three directions, some attacking only root systems, some bark and the other the sap and heart wood of the stem. (2) Scavenging termites, removing the decaying and dead parts of the bush, these are therefore secondary pests. (3) Those, including the mound building termites, restricting their activities only to the soil.

Population studies of some of the species show that while the populations of mound building termites reach their peaks during July to September, in live wood and scavenging termites such peaks are reached during the cold weather. The earthen runs of the live wood termite extend at the rate of 7-10 cm per 24 hours during October-November against 1-3 cm during March-April.

(X8) **Nematological investigations :**

In addition to the three common root knots, *Meloidogyne hapla*, *M. javanica* and *M. incognita acrita*, the following genera of parasitic eelworms were isolated from nursery soil.

Family : Hoplolamidae

1. *Hoplolaimus* sp.
2. *Helicotylenchus* sp.
3. *Rotylenchus* sp.

Family : Tylenchidae

4. *Tylenchus* sp.
5. *Tylenchorhynchus* sp.
6. *Psilenchus* sp.

Family : Aphelenchoididae

7. *Aphelenchoides* sp.

Family : Dorylamidae

8. *Xiphinema* sp.

From around the roots of mature tea bushes *Hoplolaimus* sp., *Rotylenchus* sp. and *Paratylenchus* sp. were isolated. The last named genus has not been obtained from nurseries. The specific identifications, biology of several important genera and their pathogenicity are being studied.

(N8) **Tea soil fauna :**

Soil up to a depth of 10 cm was sampled four times a month from areas with mature tea over 25 years old. The samples were processed in the laboratory in a modified Tullgren funnel. Monthly variations in the populations of soil mites and insects in the samples are shown in Fig. 5.

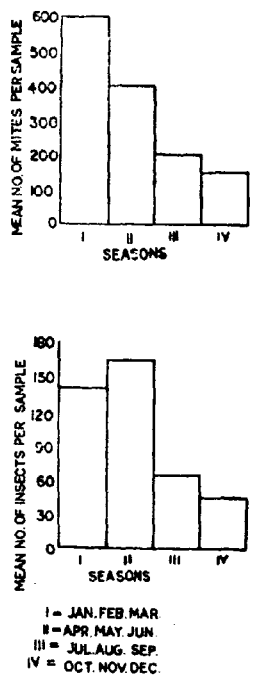


Fig. 5. Seasonal variation in the populations of soil mites and insects.

Ten different varieties of humus forming diplopods, both Iulids and Polydesmids were obtained. More of these diplopods came to the surface soil during the rainy season than at any other time.

MYCOLOGY DEPARTMENT

G. SATYANARAYANA–Mycologist

STAFF

The Mycologist was on Annual leave from 4. 4. 1966 to 4. 5. 66.

No change in staff.

RESEARCH AND EXPERIMENT

(M1) **Spraying trials against Red rust** (*Cephaleuros parasitica*) :

(a) Five chemical formulations viz. Copper sandoz, Fycol 8E, Zincop, Ferbam and Zineb were tested for their prophylactic efficiency against Red rust on two different gardens at 0.25% concentration sprayed in two rounds at 15 day intervals, using Knapsack sprayers. Assessments were made during May-June. At one garden the superiority of the copper based sprays confirms previous results. Because the incidence of the Red rust infection was low on the other garden, the results were not analysed. Copper fungicides sprayed at weekly intervals as against 15 day intervals did significantly reduce the incidence of disease.

(b) A comparison was made between the spraying efficiency of a pressure retaining knapsack sprayer which is in general use in the tea gardens and the Fontan (a power sprayer) for a second time on a Moran garden (Ann. Rep. 1965) using Copper Sandoz and Cuman against Red rust. Fontan is more efficient for spraying than knapsack sprayers using the same amount of chemical (2.5 kg/ha). Though Cuman significantly reduced the infection rate, it is clearly inferior to copper fungicide.

(M2) **Branch canker** (*Poria hypobrunnea*) :

In December 1966 four chemicals, viz. Santar A, Esso Fruit Tree Grease, Indopaste and a Copper fungicide as paste were applied against *Poria* at Tocklai to the cut surfaces of pruned branches. The incidence and development of the disease will be assessed during the next cold weather.

During the year in review a marked shortage in the supply of Indopaste was observed and hence the study was undertaken using possible alternatives.

Thorny stem blight (*Tunstallia aculeata*) :

The effect of top spraying of a copper fungicide on heavy pruned tea followed by indopasting of the cut surface of pruned branches as a prophy-

lactic measure against Thorny stem blight of tea is being continued to be observed in Darjeeling.

Effect of N. P. K. fertilizer on the disease incidence is under study in one Darjeeling garden.

(M3) **Black rot** (*Corticium invisum*) :

Nine formulations, viz. Copper Sandoz, Ferbam, Zincop, Zineb, Fytol 8E, Brassicol, Daconil 2787, Nickel chloride and Cuman have been applied prophylactically (April-May) on a garden in the Dibrugarh district at intervals of 2 weeks in two rounds. The assessments were made during July. All the chemicals with the exception of Ferbam decreased the disease incidence significantly. Copper fungicides are indeed, superior to all these other formulations tested.

(M4) **Root rots :**

Cross pathogenicity experiments started in 1963 with Brown root rot and Charcoal stump rot on tea have not yielded any positive results so far.

Purple root rot (*Helicobasidium compactum*).

The trial on one North Bank garden for the control of Purple root rot is still under observation.

(M5) **Aerobiological Distribution :** A start has been made in assessing daily atmospheric spore catches using two modified Derham traps, one being situated at Tocklai and the other at Borbhetta. It is hoped thereby to observe any correlation between meteorological data and disease incidence as a possible method of disease forecasting.

Shade and Nutrient experiment at Murmuria (BAS 20) :

The incidence of Red rust and Black rot were visually assessed and the experiment will further be observed during the next year. No definite conclusions are possible at present.

GENERAL REMARKS

(i) Purple root rot (*Helicobasidium compactum*) has been recorded on *Crotalaria anagyroides* and *Priotropis* sp., both observations being new records.

(ii) A colour test is under development to detect the degree of contamination in the factories using a chemical 2, 3, 5, Triphenyl tetrazolium chloride (TTC). The chemical develops a red colour in the presence of any living organic matter. Colour developed is directly proportional to the contamination present.

ADVISORY

Touring— The Mycologist attended the 53rd Indian Science Congress at Chandigarh.

Lectures— Lectures were given during the Field Management and Use of Agricultural Chemicals, courses held at Tocklai.

Trainees— The following were trained in the identification and control of tea diseases :

9 trainees undergoing one year course at Tocklai.
6 V. P. trainees.
2 Scientific Officers of Agency Houses.

PESTICIDE DEPARTMENT

T. D. MUKERJEA — Pesticide Testing Officer

STAFF

No change in staff complement. Pesticide Testing officer was on Annual leave from 19th to 31st December 1966.

RESEARCH AND EXPERIMENT

SCREENING OF PESTICIDES

(Pl) **Acaricides :**

Evaluation of new acaricides received in 1966 was carried out against different mite pests of tea.

New acaricides against Red spider—Field trials were conducted against Red spider using Ethion, Metasystox, Trithion, Morocide, Morestan, Mesurol at the rate of 1.25 l/ha and Malathion @ 2.5 l/ha. The experimental area was located in a section of mature tea comprising a total area of 0.4 hectare. The treatments were applied with 'Fontan' power sprayer on randomised plots replicated five times with similar control plots left unsprayed. The observations were recorded at an interval of 7 days over a period of one month between 14. 5. 66 to 13. 6. 66.

Results—After one week of spraying all the treatments were found to reduce the number of living mites significantly over the control. After a fortnight from the date of spraying, Morocide was no better than the control and other treatments were equitoxic and significantly better than Morocide. Further, after a third and fourth week of spraying, Morestan, Ethion, Malathion, Metasystox and Trithion were equitoxic and significantly better than Morocide and Mesurol. After one month of spraying, Ethion, Morestan, Malathion, Trithion, Morocide and Mesurol showed a percentage mortality of 100, 97, 95, 88, 68 and 40 respectively.

Conclusion,

1. Persistence of Ethion, Metasystox, Morestan, Trithion and Malathion at the doses used during the rains is high and remain effective for over a month.

2. Morocide and Mesurol lose their persistence after one week and their effectiveness is progressively reduced.

New acaricides for the control of Scarlet mite—Morocide E. C. and Morestan W. P. were found to be very promising acaricides and gave as good a protection as did Kelthane (Ann. Rept. 1965).

In order to compare their efficacy and persistence with that of newer acaricides a field trial was laid out in a section which was uniformly and heavily infested with Scarlet mite. Treatments were replicated five times with similar control plots left unsprayed.

Morocide and Morestan were applied at the rate of 1.25 l ha only once, whereas Ethion, Tedion, Trithion and Mesurol were applied at the rate of 1. 25 l ha twice at an interval of 15 days. The observations were recorded at an interval of 7 days over a period of $2\frac{1}{2}$ months between 5. 2. 66 to 16. 4. 66.

Results—After one week of spraying all the six acaricides were found to reduce the number of living mites significantly in comparison with control, and Morocide and Morestan were significantly better than all other treatments. After a fortnight, Morocide and Morestan continued to give best control and were equitoxic and there was no significant difference between them. After second application of Ethion, Tedion, Trithion and Mesurol, in the third count after 3 weeks of spraying, Mesurol was significantly better than Ethion, Tedion and Trithion and equitoxic with Morocide and Morestan. In successive counts up to $2\frac{1}{2}$ months all the treatments continued to register significantly high mortality of Scarlet mites and there was no significant difference amongst them. After $2\frac{1}{2}$ months Morocide, Ethion, Mesurol, Morestan, Trithion and Tedion showed a percentage mortality of 98, 97, 96, 94, 89 and 88 respectively.

Conclusion.

1. Morocide and Morestan, though applied only once in February when there is normally very little rain, remain toxic and persistent for over a period of $2\frac{1}{2}$ months.

2. The effectiveness of Ethion and Mesurol a week after their second application improved considerably and were equitoxic with Morestan and Morocide and continued to remain so up to a period of $2\frac{1}{2}$ months.

3. Tedion which was hitherto considered an ineffective acaricide against Scarlet mite showed that after its second application within a fortnight its effectiveness improves progressively.

One vs. Two applications of acaricides against Scarlet mite—Kelthane E. C. is known to be highly effective against Scarlet mite. Esso Tree Spray Oil has shown good promise. In order to determine whether two applications of Esso Tree Spray Oil, Akar, Lime sulphur, Rogor and

Ekatin will improve the effectiveness and persistence as against one application of Kelthane, a comparative field trial was carried out in a section which was uniformly and heavily infested with Scarlet mite. Treatments were replicated five times with similar control plots left unsprayed. Kelthane was sprayed @ 1. 25 l/ha only once. Rogor, Ekatin and Akar @ 1.25 l/ha and Esso Tree Spray Oil and Lime sulphur @ 12.5 l/ha and 28.5 l/ha respectively were sprayed twice at an interval of 15 days.

The observations were recorded every week over a period of $2\frac{1}{2}$ months between 3. 2. 66 and 18. 4. 66.

Result :—After one week of first spraying all the treatments significantly reduced the Scarlet mite population over the control. Best results were obtained with Kelthane, Esso Tree Spray Oil and Lime sulphur and were equitoxic. These were also significantly better than Rogor, Akar and Ekatin. After two weeks of first spraying Kelthane, Esso Tree Spray Oil, Akar and Lime sulphur were equitoxic and significantly better than Rogor and Ekatin. One week after second application, except Ekatin and Rogor all the treatments improved considerably and were equitoxic, but Akar and Lime sulphur were not significantly better than Rogor. Two weeks after second application, Kelthane, Esso Tree Spray Oil, Akar and Lime sulphur were significantly better than Ekatin and Rogor and there was no significant difference between them. The persistence of Rogor and Ekatin fell abruptly and they were no better than control. In successive counts up to $2\frac{1}{2}$ months, Kelthane, Esso Tree Spray Oil, Akar and Lime sulphur continued to show significantly high mortality of Scarlet mites and they were equitoxic and significantly better than Rogor and Ekatin. In fact in Ekatin treated plots, the Scarlet mite population was almost same as control plot.

After $2\frac{1}{2}$ months Kelthane, Esso Tree Spray Oil, Akar, Lime sulphur, Rogor and Ekatin showed a percentage mortality of 97, 96, 94, 93, 35 and 13 respectively.

Conclusion.

1. Kelthane sprayed only once in February when there is little rain, was highly effective against Scarlet mite and its persistence lasted over a period of $2\frac{1}{2}$ months.

2. Esso Tree Spray Oil, Akar, Lime sulphur sprayed twice at an interval of 15 days during the same period were highly persistent and were equally effective as Kelthane up to a period of $2\frac{1}{2}$ months.

3. Rogor was effective up to two weeks after first spraying but did not improve after second application and continued to lose its persistence till the end i. e. $2\frac{1}{2}$ months.

4. Ekatin was worst of all the acaricides used and its persistence progressively reduced even after two applications within a fortnight.

New acaricides for control of Pink mite—Kelthane E.C. and Akar 338 are known to be effective against Pink mite. Ethion E. C. was found to be promising and gave a good protection as did Kelthane and Akar (Ann. Rep. 1965).

In order to compare the efficacy of Ethion (1.25 l/ha), Esso Tree Spray Oil (12.5 l/ha, 6.25 l/ha and 3.125 l/ha) and Tedion (1.25 l/ha) with that of Kelthane E. C. (1.25 l/ha) and Akar (1.25 l/ha), a field trial was laid out in a section which was evenly and moderately infested with Pink mite. Treatments were replicated five times with similar control plots left unsprayed. Observations were recorded every week over a period of one month between 16. 7. 67 and 16. 8. 67.

Result—In all the four counts during the period of four weeks, all the acaricides were found significantly better than control and there was no significant difference between them. After one month of spraying, Kelthane, Ethion, Akar, Esso Tree Spray Oil (12. 5 l, 6. 25 l and 3. 125 l per ha) and Tedion showed a percentage mortality of 100, 99, 98, 97, 97, 97 and 96 respectively.

Conclusion.

1. Ethion, Esso Tree Spray Oil and Tedion, at the doses used were highly effective against Pink mite and their persistence and effectiveness is comparable with that of Kelthane and Akar.

2. Esso Tree Spray Oil even at the lowest dose of 3 l/ha was as effective and persistent as Kelthane, Ethion and Akar against Pink mite.

Acaricides for the control of Purple mite—Field trials were conducted against Purple mite using Kelthane, Roger, Ekatin, Akar at the rate of 1.25 l/ha; and Esso Tree Spray Oil and Lime sulphur @12.5 l/ha and 28.5 l/ha respectively. The experimental area was located in a section of mature tea comprising a total area of 0.4 hectare. The treatments were applied with Fontan power sprayer on randomised plots replicated five times with similar control plots left unsprayed. The observations were recorded at an interval of 7 days, over a period of one month between 3.2.66 and 3. 3. 66.

Result—After one week of spraying all the six chemical treatments were significantly better than the control and were equitoxic. After two weeks, Kelthane, Esso Tree Spray Oil, Akar and Lime sulphur were significantly better than Rogor and Ekatin. Rogor and Ekatin were, however, superior to control but there was no significant difference amongst them. In the successive counts in third and fourth week after spraying Kelthane, Esso Tree Spray Oil, Akar and Lime sulphur maintained their persistence and effectiveness and were equitoxic. Rogor and Ekatin progressively deteriorated and at the end Ekatin was no better than control. After one month, Esso Tree Spray Oil, Kelthane, Akar, Lime sulphur, Rogor and Ekatin showed a percentage mortality of 100, 99, 98, 88, 38 and 37 respectively.

Conclusion.

1. Kelthane, Esso Tree Spray Oil, Akar and Lime sulphur at the doses used were highly effective against Purple mite and these remained persistent up to a period of one month.
2. Rogor and Ekatin were partially effective up to two weeks. After two weeks these lost their effectiveness progressively and at the end of the month they were no better than control.

Insecticides :

Comparative efficacy of Malathion, Rogor, Ekatin, Chlordane and Dimecron against Scale insect (*Fiorinia theae*) — Malathion is known to control Scale insects. Rogor, Ekatin and Dimecron, the systemic insecticides, were tried this year in comparison with Malathion and Chlordane for the control of Scale insect. The trial was conducted on a mature tea in a section which was moderately infested with Scale insects. Spray was applied with Fontan power sprayer on randomised plots replicated five times with similar plots left unsprayed. All the treatments were applied 1.25 l/ha. The observations were recorded at an interval of 7 days over a period of one month between 4. 2. 66 and 7. 3. 66.

Results- All the five treatments were found to reduce the population of Scales significantly over the control at one week after the application of treatments. Best results were obtained with Malathion, Chlordane and Rogor and these were significantly better than Ekatin and Dimecron. After two weeks of spraying they were equitoxic but significantly better than control. After one month Rogor was significantly better than all other treatments. After one month, Rogor, Dimecron, Malathion, Ekatin and Chlordane showed a percentage mortality of 96, 75, 72, 71 and 67, respectively.

Conclusion.

1. Malathion gave a better initial kill of scales but lost its persistence progressively at the end of the month.
2. Rogor did not show a high initial kill but improved progressively and gave highest kill at the end of the month.
3. Chlordane, Ekatin and Dimecron were equitoxic with Malathion but inferior to Rogor.

New insecticides for the control of *Helopeltis theivora*—Thiodan, a new hydrocarbon insecticide and Anthio, an organophosphate were tried this year in comparison with the standard insecticides. DDT and Dieldrin for the control of *Helopeltis theivora* of tea.

The trial was conducted in the Dooars on mature tea in a section which was moderately infested with *Helopeltis theivora*. DDT, Dieldrin and Thiodan were applied @ 2.5 l/ha and Anthio @ 3.75 l/ha with Holder Harriden knapsack sprayer. The chemicals were applied on randomised plots replicated five times. The observations were recorded at an interval of 7 days over a period of 15 days between 14. 10. 66 and 29. 10. 66.

Result - After one week of spraying, best result was obtained with DDT, and it was significantly better than Thiodan, Anthio, Rogor and Dieldrex. There was, however, no significant difference between Anthio, Rogor and Dieldrex. After two weeks all the treatments were significantly better than control and there was no significant difference amongst them.

At the end of two weeks, DDT, Dieldrin, Thiodan, Anthio and Rogor showed a mortality percentage of 97, 95, 88, 86 and 84 respectively.

Fungicides :

Nickel chloride, Cuprocol and Foroplant against Blister blight—A field trial was laid out in Darjeeling in a section where infestation of Blister blight had occurred every year and bushes were pruned in cold weather of 1965. Altogether four rounds of spraying were given at an interval of 7 days.

Statistical analysis of the results has yielded the following information:

1. That Nickel chloride at the rate of 3.75 kg/ha and 2.5 kg/ha and Cuprocol at the rate of 2.5 kg/ha were superior to Foroplant in effectiveness but Cuprocol was quicker in action than that of Nickel chloride.
2. That after four rounds of spraying both the concentrations of Nickel chloride were equitoxic and that there was no significant difference in their efficacy up to a period of 1 month after application of last round.

3. Foroplant was slow in action and lost its persistence progressively.

Nematicides :

Comparative efficacy of different nematicides against Root knot nematodes in Tea—It has been established that Nemagon is the best nematicides so far used and is an economic proposition. Hexa-Nema and Vapam which were tried before but did not prove to be better than Nemagon at the doses used. A new granular formulation of EDB was received this year for comparing its efficacy against Nemagon and a field trial was laid out at Tocklai. The granular EDB was used @ 380 kg. per hectare. The experimental design was a randomised block with five replications of each treatment with control plots left untreated.

Statistical analysis of the results has yielded the following information:

a. The percentage of plants free from root-knot was significantly higher in Nemagon and EDB granular treated plots than the untreated control.

b. The root-knot indices were significantly lower in Nemagon and EDB granular treated plots.

c. Number of seedlings which reached plantable size were significantly greater in Nemagon treated plots than in EDB granular treated plots.

(P4) **Taints of Made Tea Due To Application of Pesticides :**

Trithion E. C., Sulkol and Cuman were tested to find out whether they taint the made tea. With the exception of Sulkol, others do not taint tea.

(P5) **Residue :**

Field trials were conducted during dry and wet weather condition to evaluate residue of Trithion, Morocide, Morestan and Mesurol. The results are awaited.

(P6) Eelworm (Nematodes) :

Ectoparasitic spiral nematodes — ***Rotylenchus* sp., *Helicotylenchus* sp., *Hoplolaimus*** sp. ectoparasitic spiral nematodes have been isolated in large numbers around the roots of stunted tea seedlings in nursery beds. Their suspected pathogenecity in tea seedlings is being investigated.

CERTIFICATION OF PESTICIDES AND HERBICIDES

During the year 6 new products were received for official tests. Certificate of Approval for 13 products were issued and 14 Certificates were renewed.

BIOCHEMISTRY DEPARTMENT

S. B. DEB—IN-CHARGE

STAFF

Dr. S. L. Mukherjee joined the department as Biochemist in March, 1966 and resigned from the Association's service in August, 1966. Subsequently Mr. S. B. Deb has been in charge of the department.

Mr. K. C. Jaiswal, Stenographer, was transferred from the Directorate to this department in October, 1966.

RESEARCH AND EXPERIMENT

(C 1) **Chemical Constituents of Tea Leaf :**

Flavour components — Aroma is a complex mixture of aldehydes, ketones, esters, alcohols and hydrocarbons both aliphatic and aromatic. Green tea leaf growing on the bush has no aroma; it is developed only when the leaf is processed for the manufacture of tea.

Fresh Betjan leaf was finely minced and kept immersed in low boiling petroleum spirit for about 15 days. The solvent was then distilled off to obtain a concentrate rich in aroma producing compounds. This was then fractionated by column chromatography using Brockmann alumina as adsorbent. The column was developed by solvents either in the pure state or in mixtures. The solvents used were low boiling petroleum spirit, benzene and alcohol.

As many as 150 fractions of effluents were collected, some of which, on removing the solvents, produced the characteristic odours of citronellol and geraniol. Thin layer chromatography using silica gel revealed the presence of citronellol and geraniol. Besides the above substances, some of the effluents, on removal of solvents at room temperature, produced white solid compounds having definite melting points and pleasant odours. Some other coloured solid compounds were also obtained which await purification and study.

Differentiation of Flavoury and non-Flavoury Teas — Preliminary experiments have been carried out to distinguish flavoury (Darjeeling) and non-flavoury (Assam) teas. The volatile matters from these teas were steam distilled and dinitrophenylhydrazine (DNP)

derivatives of the carbonyl compounds present therein were prepared by bubbling the distillate through DNP solutions. Study of the absorption spectra of these DNP derivatives in alcohol revealed that there was not much difference in the carbonyl compounds of the two types of teas.

Attempts were made to differentiate the teas in respect of their aldehyde and alcohol contents. 50 g of each type of teas were finely powdered and refluxed with 300 ml of petroleum spirit for 4-5 hours. The extracts were evaporated and the materials examined spectrophotometrically after suitable colour development, using reagents specific for the test of aldehyde and alcohol. It was observed that there was no sharp difference between the two types of teas.

The materials were then dissolved in acetic acid and in chloroform. The spectral absorptions were recorded from 250 mμ to 510 mμ. Both types of teas showed absorption maxima at 270 mμ and 445 mμ; but Assam teas had higher absorption than the Darjeeling teas at all wave lengths. It is difficult at this stage to make any statement regarding this difference and an extensive study of a large number of flavoury and non-flavoury teas from various sources need to be undertaken before arriving at any definite conclusion.

Polyphenols :

Biosynthesis of Polyphenols — Complementary to our observation [1] on the fall in sugar content and the consequent increase in the phenolic matter at the end of the night, further work to study the role of sugars in the biosynthesis of polyphenols in tea leaf was undertaken.

All the experiments were carried out in the laboratory at room temperature (28° - 32°C). Tea shoots were plucked and a part of these was dried immediately. This part was used as the control sample. Shoots from the rest of the sample were fed separately with glucose and sucrose solutions of different concentrations for 24 hours, after which each lot was dried. The individual polyphenols were estimated in both the treated and the untreated dried samples. The treated samples were found to contain higher amounts of polyphenols than the corresponding control samples. At the same time, it was observed that a decrease in the quantity of sugars used in the solutions for feeding the samples occurred. The fall in the concentration of the sugars and the increase in the phenolic content of the treated samples might have resulted from the utilization of a part of the sugars absorbed by the shoots in the synthesis of the polyphenols.

During the 24 hour period of the above experiment, the samples were left in daylight followed by night and finally in daylight. So the synthesis of the polyphenols took place in alternate presence and absence of photosynthesis. In the dark period, in absence of photosynthesis, no extra sugar could have been produced although the loss in sugar owing to respiration of the tea shoots continued throughout the period. In order to study the synthesis of the polyphenols in the presence of continuous photosynthesis, tea shoots fed with glucose solution were exposed to light from a 100 watt electric light bulb throughout the 24 hour period. Estimation of the polyphenols revealed definite increase in the phenolic content of the fully lighted samples over their controls (leaf dried immediately after plucking).

In our experiments on the time of plucking of tea shoots [1], a high degree of biosynthesis of polyphenols from the sugar accumulated in the day time through photosynthesis, appeared to have taken place in darkness during the night. In order to study the biosynthesis of polyphenols in darkness tea shoots were fed with glucose solutions and kept in darkness for 24 hours under laboratory conditions. A similar set of samples was also kept under light for the same period. The phenolic contents of the samples kept in darkness as well as in light increased over their controls. There was however, no significant difference in the degree of biosynthesis of polyphenols between samples under light and darkness. More precise study would, however, be necessary on this.

The effect of different radiations on the synthesis of polyphenols in tea shoots fed with glucose solution was also studied by keeping the samples under (i) ultra violet lamp (3 hr), ordinary electric light (18 hr) and finally ultra violet lamp (3 hr); ii) infra red lamp (3 hr), ordinary electric light (18 hr) and finally infra red lamp (3 hr); iii) ultra violet lamp in combination with ordinary electric light (18 hr) and (iv) infra red lamp in combination with ordinary electric light (18 hr). The phenolic content in each of the treated samples was found to increase compared to that in the corresponding controls. It was however observed that ultra violet in combination with ordinary light seemed to enhance the degree of synthesis of the polyphenols.

From the foregoing study, it has been affirmed that sugar plays specific role in the biosynthesis of polyphenols. Optimum photosynthesis is likely to produce a greater amount of sugar in the tea plant and thus a higher phenolic content may be expected to result, which in turn, would reflect in liquor characters of made teas.

(C 5) **Chemical Assessment and Differentiation of Clones :**

The broad aim of the project is to make biochemical assessment and differentiation of seven clones released from Tocklai by estimating those

chemical constituents of leaf and made tea that are usually considered important in determining liquoring characteristics. The study was further extended by the inclusion of one jat. As it was not possible to analyse all the eight samples in a day, they were divided into two groups of four each. Both groups were plucked at weekly intervals on Mondays and Wednesdays respectively. The teas were manufactured by the Orthodox and the C. T. C. methods in alternate fortnights. The full range of chemical analysis of the samples of leaf and corresponding teas could only be undertaken once in a fortnight.

Group I		
Tingamira	—	Commercial *Jat*
Clone 14/9	—	Tocklai vegetative clone
Clone 20/6	—	,, ,, ,,
Clone 106/1	—	,, ,, ,,
Group II		
Clone 3/77	—	Tocklai vegetative clone
Clone 20/23/1	—	,, ,, ,,
Clone 19/29/13	—	,, ,, ,,
Clone 1/7/1	—	,, ,, ,,

Analyses of fresh leaf and made tea were carried out and altogether twelve repeats were made during the season. The teas were tasted and evaluated for the important liquor characters such as colour, strength, briskness, brightness and quality by five tasters, one at Tocklai, two in Calcutta and two in London, to whom the samples were sent under coded numbers.

The analyses of leaf and tea comprised the following constituents :—

Leaf	**Made tea**
Moisture	Moisture
Total soluble solids	Total soluble solids
Total polyphenols (Lowenthal)	Total polyphenols (Lowenthal)
Water soluble nitrogen	Water soluble nitrogen
Caffeine nitrogen	Caffeine nitrogen
Total nitrogen	Total nitrogen
Protein nitrogen	Protein nitrogen
Enzyme activity (QO_2)	Ash
Total uptake	Crude fibre
Individual polyphenols	Creaming Index (C. I.)
	Theaflavins (TF)
	Thearubigins (TR)

There was little variation in moisture content of the leaf during the season. Seasonal variation of some of the important ingredients was apparent though on many occasions the variation was haphazard. A progressive fall in total polyphenols, caffeine etc. was evident during the latter half of the season. Though very high values for oxidase activity were obtained during the early part of the season, as well as in August, they decreased during the latter part. It is the general experience that North East India produces its best teas during second flush and thereafter the quality deteriorates. The reasons for this failing off appear to be complex, but it seems likely that one of the causes is a drop in the amount of polyphenols and their oxidation products associated with the decrease in enzyme activity of the fresh leaf.

The average values for some important chemical ingredients of leaves and corresponding made teas from one *jat* and seven clones calculated on dry weight basis, are presented in Table I.

Table 1. The average values for some important ingredients in leaves and corresponding teas from Tingamira Jat and seven clones calculated on dry weight basis.

Leaf	Jat Tinga-mira	Clone 14/9	Clone 20/6	Clone 106/1	Clone 3/77	Clone 20/23/1	Clone 19/29/13	Clone 1/7/1
Soluble solids	48.3	48.9	48.8	48.7	49.6	50.2	50.3	50.7
Total Polyphenols (Lowenthal)	32.9	32.9	32.4	33.9	33.2	36.5	36.3	38.0
$Q0_2$	17.70	17.65	16.60	18.59	15.90	19.53	19.14	15.34
$Q0_2$ X total uptake	162.50	163.50	155.90	169.90	151.10	205.40	228.50	157.70
Caffeine	3.36	3.07	3.22	3.64	3.03	3.78	3.32	3 54
Protein nitrogen	2.41	2.05	2.24	2.31	2.33	2.18	1.99	2.04
Made tea-Orthodox								
TF	0.79	0.59	0.84	0.75	0.67	1.03	0.89	0.68
TR	10.09	11.88	10.97	10.33	9.34	11.06	11.63	9.93
TF/TR	0.07	0.05	0.08	0.07	0.07	0.09	0.08	0 07
C. I.	25.80	42.30	27.40	25.50	24.00	29.00	34.40	26.90
Made tea-C. T. C.								
TF	1.64	1.13	1.77	1.87	1.39	2.14	1.72	1.70
TR	18.27	20.29	16.15	18.26	15.82	17.69	20.28	18.13
TF/TR	0.09	0.05	0.11	0.10	0.09	0.12	0.09	0.09
C. I.	51.90	65.60	40.50	47.10	39.60	49.70	63.90	47.80

It is apparent from the table that the variations in the soluble solids between clones are not so wide as to be of significance but polyphenols (oxidisables) vary widely between 32.4% and 38.0%.

As only three of the polyphenols contained in tea leaf are oxidised during the process of fermentation, an estimate of these phenols is given by the figures for total uptake measured with the Warburg apparatus. The important role played by enzyme activity and phenolic content of the leaf in determining some of the liquor characters is an admitted fact. The value of the product of enzyme activity and total uptake gives an indication of the fermenting property of the leaf and some of the liquor characters, such as strength and colour. Thus, the higher the analytical values the more pronounced will these characters be in the liquors.

Considering the clonal and the Tingamira *jat* leaves the variations in QO_2 and the products of QO_2 and total uptake, are appreciable. The rates of fermentation for clones 20/23/1 and 19/29/13 are very high and are nearly the same. Clone 1/7/1 has the lowest QO_2 value but the highest quantity of total polyphenols, indicating that it would produce teas with some strength although its rate of fermentation is low. There are also wide variations in the product of QO_2 and total uptake, ranging from 151.1 for clone 3/77 to 228.5 for clone 19/29/13. Thus the clone 3/77 having very low values for enzyme activity and the product of enzyme activity and total uptake should ferment slowest of all the seven clones that have been analysed and the colour of tea made from this clone was, in fact, always been greenish.

The variation in protein nitrogen, although irregular, shows a tendency to increase with the advancement of the season. The clones which produce teas having good liquor characters contain on an average a low protein nitrogen content. This low protein nitrogen content may also be of importance when relating quality of tea to chemical composition.

The detailed interpretation of the results and their correlation with tasters' findings for different characters are awaiting statistical computation.

ADVISORY

Touring — The Biochemist was on tour to New Delhi from 15th to 18th March, 1966 to attend a meeting of the Indian Standards Institution held in connection with drawing the specification for black tea.

Testing of samples — 145 samples of tea were tested during the year.

Correspondence — 322 letters were issued during the year of which 84 were of advisory nature.

Reference

[1] Annual Report, (1965), Tocklai Experimental Station, pages 91—94.

MANUFACTURING ADVISORY & TEA TASTING DEPARTMENT

R. CHOUDHURY — Manufacturing Adviser & Tea Taster
S. K. BANERJEE — Second Tea Taster.

(T1). **Tasting**—During the year a total of 27,980 samples were tasted. The following are the breakdown figures :-

Departments	No. of samples
Manufacturing Advisory & Tea Tasting Dept.	87
Agriculture Dept	638
Advisory Dept	274
Botany Dept	3,529
Pesticide Testing Dept	27
Engineering Development Dept.	947
Experimental Station, W. B. Mal	1,140
Total	6,642
Manufacturing Advisory (Muster) samples	3,864
Clonal samples sent by estates	17,474
Grand Total	27,980

(T2). Manufacture and tasting experimental samples received from the following departments :—

(1). **Manufacturing Advisory & Tea Tasting Department :**

(i) **Chemical wither** — Experiments carried out in the past with leaf from *jats* have indicated that it is necessary to store the leaves at least for 15 hours before rolling even if the desired physical wither can be obtained by artificial means in 2½ hrs. The object of this experiment was to find out whether this required storage period is different for clones.

Leaves were plucked from the clones TV1 (19. 29. 13), TV2 (20. 23.1), TV8 (3.77) and Betjan *jat* and brought to the factory in the shortest possible time. The leaves from each of the clones and the *jat* were then divided into 4 lots. Three lots were stored thickly (about 10 cm (4") thick) before withering them in the tunnel. Storage times for these were taken as the total time between plucking and rolling and were 9 hrs, 15 hrs and 18 hrs. The conditions in the tunnel was so adjusted that all the three samples stored for different length of time were withered approximately to the same degree (75%).

The fourth sample was withered naturally.

The valuations given by the Tocklai Taster to the different treatments are given in Table 1.

Table 1. Average valuations for different hours of storage (1966) in Rs./kg of made tea

Taster : Tocklai

Clone	Treatments				Critical difference at		C.V %
	9 hrs	15 hrs	18 hrs	Natural wither (approx 20 hrs	5%	1%	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Betjan	5.50	5.95	5 .96	6.02	0.38	0.54	4.2
TV1 19.29.13	5.90	6.18	6.46	6.40	0.30	0.42	3.2
TV2 20.23.1	5.78	6.01	6.18	6.12	0.22	0.30	2.2
TV3 3.77	5 16	5.82	5.88	5.86	0.22	0.30	2.4

From the above table it can be seen that there is no significant difference between the samples stored for 15 hours, 18 hours and Natural wither while the samples stored for 9 hours are significantly inferior in value compared to the other treatments.

Therefore for clones as for *jats* it is desirable to store the leaves for at least 15 hours prior to green leaf processing.

(2). **Manufacture and assessment of teas from experiments of the Agriculture Department :**

Leaf samples from plots under different pruning cycles with varying degrees of severity (prune, deep skiff , edium, kiff Expt. B15/1.1) were manufactured and tasted. No significant difference was obtained between the treatments.

Teas tipped at varying heights between 10 cm - 20 cm (Expt. B20) were manufactured and tasted but no significant difference was obtained between the samples.

Plots receiving 90 kg, 135 kg and 180 kg nitrogen/ha in the form of sulphate of ammonia (Expt. B104) were sampled for manufacture and tasting. No significant difference was obtained between the treatments.

Samples from treatments receiving different combinations of nitrogen, phosphate and potassium (Expt. B112) were tasted. Teas receiving 90 kg/ha of each of nitrogen, phosphate and potassium gave higher valuations than the teas receiving nitrogen alone.

Leaf samples from plots receiving nitrogen at the rate of 90 kg/ha in the form of ammonium sulphate nitrate, urea and sulphate of ammonia (Expt. B111.1) were manufactured. Application of sulphate of ammonia did not show any difference in the valuation of the made teas as compared to those from the control (no manure) plots. Urea, however, gave significantly lower valuations compared to calcium ammonium nitrate and control.

(3). Manufacture and assessment of teas from experiments of the Advisory Department :

N_{122} PO. $K_{22\cdot5}$ and $N_{112}P_{224}$ and K_{224} produced significantly superior teas compared to the tea made from plots receiving nitrogen alone at the rate of 112 kg/ha (Expt. AS44).

It is interesting to note that similar results were obtained in experiment B112 mentioned earlier.

Leaf samples from plots receiving 112 kg nitrogen/ha and 217 kg nitrogen/ha applied in single and divided doses were manufactured. Teas from both the nitrogen levels applied in one dose did not have any significant difference in quality. When the higher level of nitrogen was applied in divided doses in eight monthly applications there was no significant difference in the valuation of the teas from the single dose, but when 112 kg nitrogen/ha was applied in divided doses in four monthly applications the quality was inferior to the single dose. The reason for this latter result is not understood and the matter needs further investigation.

Teas made from plots that were pruned (1 cm up), medium skiffed and deep skiffed (Expt. AS 13) had no difference in quality as already observed in Expt. B15/1.1 mentioned earlier.

The above findings of the experiments of the Agriculture and Advisory Departments are from one season's manufacture only.

(4). **Manufacture and tasting of teas from experiments of the Botany Department :**

Mother bushes for selection of Vegetative Clones, clones and progenies under long term trials and samples from C-5 experiment were tasted.

The object of the C—5 experiment is to find out if there is any relation between taster's assessment of liquor characters and chemical constituents of green leaf or made tea.

(5). **Manufacture and tasting of teas from experiments of the Pesticide Department :**

120 samples were manufactured for residue trials and 27 samples were manufactured and tasted for tainting.

(T3). **Testing of commercial products :**

(1). "Safo" cleansing powder supplied by Industrial supply Agency (26, Gopi Mohon Dutta Lane, Calcutta-3) was tested and found suitable for use in tea factories, for cleansing fermenting surfaces and green leaf processing machines.

(2). P. V. C. Belting manufactured by Industrial Rubber Products (The Dunlop Rubber Co. (India) Ltd., 62 - A, Free School Street, Calcutta) did not impart any taint to the made teas and was found suitable for use in tea factories as conveyor belts. However, it was suggested that making the material a little more flexible would be of help.

ADVISORY

Touring — The Manufacturing Adviser & Tea Taster visited 114 factories in Assam, Dooars and Darjeeling for advising on manufacture and group tasting of teas were held on four occasions in four different circles.

Lectures — Two lecture courses on Factory Management and two lecture courses on Miniature Manufacture together with demonstrations were conducted by the Department in co-operation with the Biochemistry and Engineering Development Departments.

Survey — A survey was undertaken to find out the quantity of tea made by different methods for the seasons 1964 and 1965 in N. E. India (excluding Darjeeling). Tables 2, 3 and graphs I, II, and III show the trend.

Table 2. **N. E. India**

Method of Manufacture	1963 % production	1964 % production	Increase or decrease compared to 1963	1965 % production	Increase or decrease compared to 1964
Orthodox	21.52	16.61	— 4.91	19.22	+ 2.61
C. T. C.	64.76	69.15	+ 4.39	66.93	— 2.22
Legg-cut	10.07	11.52	+ 1.45	11.00	— 0.52
Rotorvane	3.65	2.70	— 0.95	2.83	+ 0.13

Table 3. **Assam**

Method of Manufacture	1963 % production	1964 % production	Increase or decrease compared to 1963	1965 % production	Increase or decrease compared to 1964
Orthodox	16.94	13.94	— 3.00	15.44	+ 1.50
C. T. C.	79.01	82.84	+ 3.83	81.03	— 1.81
Legg-cut	—	—	—	—	—
Rotorvane	4.05	3.21	— 0.84	3.52	+ 0.31

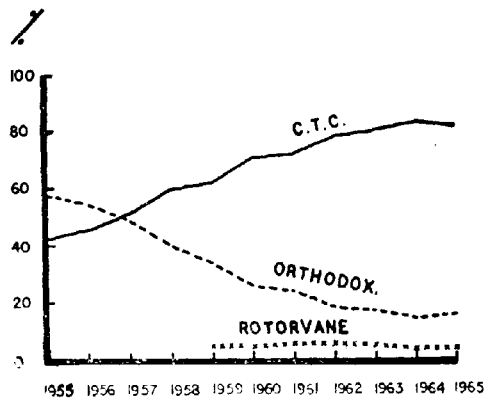
Table 4. **Dooars & Terai**

Method of Manufacture	1963 % production	1964 % production	Increase or decrease compared to 1963	1965 % production	Increase or decrease compared to 1964
Orthodox	26.20	21.45	— 4.75	26.32	+ 4.87
C. T. C.	32.65	37.52	+ 4.87	37.73	+ 0.21
Legg-cut	38.29	39.04	+ 0.75	34.12	— 4.92
Rotorvane	2.86	1.95	— 0.91	1.81	— 0.14

Total quantity of tea covered by the survey :

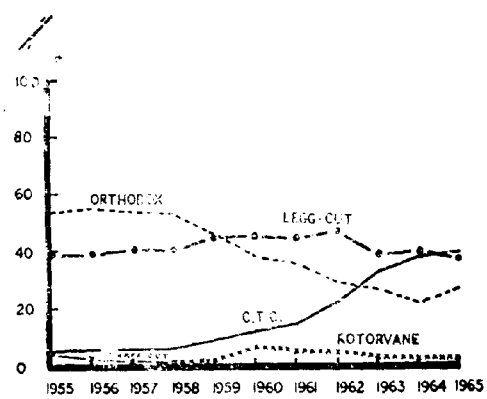
1963 = 62.57%
1964 = 61.35%
1965 = 59.59%

ASSAM

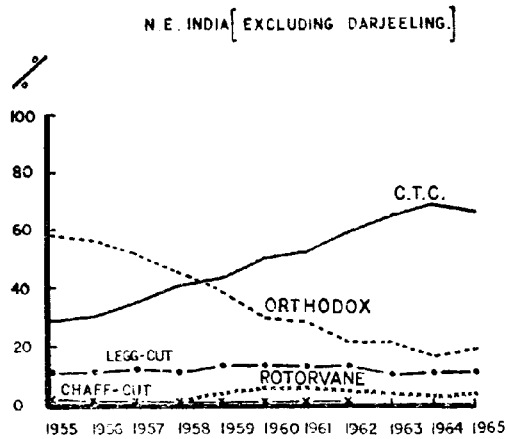


Graph I

DOOARS & TERAI



Graph II


N. E. INDIA [EXCLUDING DARJEELING.]
%
100
80
60
40
20
0
C.T.C.
ORTHODOX
LEGG-CUT
ROTORVANE
CHAFF-CUT
1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965

Graph III

ENGINEERING DEVELOPMENT DEPARTMENT

D. N. Barbora — Senior Research Engineer
A. C. Bardalaye — Second Research Engineer

STAFF

Mr. A. C. Bardalaye joined this department as the Second Research Engineer from the 8th April, 1966. There is no other change in the staff of this department.

RESEARCH & EXPERIMENT

(E2) **Fermentation : Continuous Machines :**

The 5'- Continuous Fermenting cum Drying Machine fabricated at Tocklai was in operation at Duklingia Tea Factory from the beginning of July till the 20th October, 1966. Unlike the prototype 18" fermenting cum drying machine at Tocklai where the fermenting of drying chambers are in line ahead, this 5' - fermenting chamber was mounted on top of the drying chamber to effect economy in space and also to experiment with this alternative placement of the chamber under commercial working conditions. Initial trials with the machine indicated that the units thus placed can be suitable,provided means are adapted to completely control the temperature conditions inside the fermenting chamber and that dimensions of the exhaust ducts from the drier unit are of liberal proportions. With the unit at Duklingia, conditions were studied and it was found that approximately a 4 ton refrigeration unit would suffice to dissipate the residual heat of the trays as well as heat of fermentation if the vertical arrangement of the chambers is adapted in commercial practice.

The trials indicated that better teas than those from the normal method of manufacture can be obtained from this machine if the temperature within the fermentation chamber is kept below 37°C (98°F) Dry and Wet bulb and teas are dried at a temperature of 89-92°C (190-195°F). Oxygen requirement for fermenting leaf was supplemented by leaking in 2 litres of oxygen per minute to the fermenting chamber at the prevailing temperature and pressure conditions therein. Under these sets of conditions C. T. C. teas were found to be adequately fermented within 36-38 minutes Drying time was kept at between 18 to 19 minutes.

This experiment is proposed to be continued in the next season by re-positioning the fermenting chamber in line with the drier and ahead of it to provide a longer path of travel of the empty trays through ambient air before they are re-charged with fermenting leaf on the feed end of the combined unit.

(E 3) **Moisture Content of Green Leaf :**

Preliminary investigations into the variation of electrical resistance of a tea shoot with its moisture content were started with a pair of pin type contacts kept at a standard distance of 1 cm and an ohmmeter, (measurement of line resistance). The data from these measurements indicated of contacts that with this type a relationship of the following nature between the moisture content of green leaf and its electrical line resistance exists : –

$$M = 159.11 - 29.86 \log R \pm 3.40$$

where M = Percentage Moisture

R = Resistance in ohms $\times 100$ at the 1st stem (internode) The Tocklai Statistician's report on the above data states that ".....the relationship between moisture content and resistance was exponential. The fit accounted for only 45% of the total variation. Hence the estimation of moisture content by using the above equation will not be precise. Moisture and resistance at the second stem (internode) did not show any relationship.

It was seen from the data for the same value of resistances, the measurements of moisture content showed very wide variations from shoot to shoot".

The method of measuring the resistances was next altered to measurement of bulk resistance of the 1st and the 2nd internode of the tea shoots between two discs of standard dimensions of approximately 6.5 sq. cm. (1 sq. in). The relationship under these conditions, as found by the Tocklai Statistician is as follows :—

$$M = 79.93 - 0.0363 R \pm 0.0042$$

where M = Percentage Moisture

R = Resistance (in ohms) $\times 100$

He also stated that "the fit was highly significant and the relationship between moisture content of tea leaf and resistance was linear for this set of data. The range of resistance being from 49 to 250 (in ohms $\times 100$). The fit accounted for only 45% of the total variation. Hence, the estimation of moisture content by using the above equation will not be precise."

"It was seen from the data that for the same value of resistances, the measurements of moisture content showed wide variation from leaf to leaf which was also mentioned for the previous set of data".

These preliminary studies indicated the complexity of the problem and it appears that no single method of determination of moisture will be wholly suitable for the entire range of moisture contents met with in the course of manufacture of tea shoots. More accurate meters and ovens

are necessary to correlate the actual moisture contents with the data obtained from the rapid determination of the various electrical or physical properties. Steps towards this end are being taken and the experiments to evolve a suitable instantanous or very rapid method of determination of moisture content of tea will be continued.

(E 4) **Direct Firing :**

Our investigations into this method of heating air for drying and withering tea leaf has been of necessity preliminary and general in nature, being mainly confined to studying the effects of various physical characteristics of fuel oils used in direct heaters on the resulting teas, and also studying the effects of introducing directly heated air at inlet temperature to the feed end of a drier via an underground air-duct on the liquoring properties of the resulting teas. These studies were therefore restricted to observations on commercial type of direct oil fired air-heaters now being used by the Industry on an increasingly larger scale. and include the Eastwood Direct Oil Fired Air-Heater, Steelsworth's Kilomatic Air-Heater and Williamson Magor's Direct Oil Fired Air-Heater. From our observations, it appeared that whilst all the three types of air-heaters mentioned above are capable of heating air without any trace of taint under ideal conditions, there does appear to be some uncertainty as to the quality of the products of combustion obtained which varied from day to day. The adverse effects of faulty direct oil fired air-heater running was mainly seen in the liquors of single fired teas, or those teas which were dried with direct heat in the second or final fire. This uncertain behaviour of the products of combustion in imparting taints to the teas under certain non-ideal conditions of heating and combustion needs further study. It appeared that in most cases faulty operation of the burner was found to be associated with either too low a temperature of the fuel which affects the flow conditions or too high a temperature in the flow lines affecting the chemical composition of the constituents. Alteration of the position of the preheaters to achieve a positive thermo-syphonic action or changing the preheater unit itself to achieve a positive pre-heat of approximately 60° - 71°C (140 -160°F) in the fuel oil prior to its entry into the burner appeared to eliminate most of the uncertainties relating to the quality of the products of combustion. Further work on the correlation of the physical characteristics of the furnace, air-flow etc., will however have to await acquisition by Tocklai of various measuring and recording devices for furnace temperatures, gas concentration and other flow parameters.

In order to study if there is any correlation of these defects with the composition of fuel oil and its physico-chemical characteristics, samples of Tea Drier Oils from four different estates have been drawn and sent to various fuel testing laboratories in different parts of India. The reports on these samples are still awaited.

Experiments were also conducted with the 6′ Commercial Prototype of the Tocklai Continuous Tray Drier at Hunwal T. E., to the feed area of which an underground hot-air duct was connected early this year. Calcutta brokers evaluation on C. T. C. teas dried with and without introduction of directly fired warm air into the feed-box are as follows :—

MUSTER SAMPLES

Leaf (a) **Normal** : Control- (Indirectly fired teas) Blackish brown, quite well cut with some bloom.
(b) **With Hot-Feed :** Similar, slightly browner.
(c) **Without Hot-Feed :** Most preferable having the best bloom.

Liquors : The "without hot-feed" sample is the brightest followed by 'Normal' and then Hot-feed".

The experiments and the observations on these two aspects of direct firing will be continued.

(E 5) **Continuous Green Leaf Processing Machines :**

(i) **Prototype Rotary Continuous Roller :**

Disc Type : This 76 cm (30") machine was in operation at Tocklai continuously throughout most of the season with minor modifications being evolved and it was subsequently transferred to a commercial factory (Mokrung T. E.) for a period of about 3 weeks towards the end of the manufacturing season for commercial trials.

Results of trials at Tocklai, indicated that this machine is capable of imparting a better twist to the processed leaf and it also helps preservation of tip to a large extent. Two passes through the machine appears to be necessary to obtain first fines of acceptable standard. Further work on this aspect of its processing action are being continued.

Towards the end of the season, the prototype Disc Roller was set up at Mokrung T. E., but because of the end of the season character of the plucked shoots, which made extraction of fines pointless, the experiment at Mokrung was conducted with 100% C. T. C. manufacture using the Disc Roller in the following manner :—

Treatment (1) Two passes through the Disc Roller followed by 3 cuts C. T. C.
Treatment (2) One pass through the Disc Roller followed by 3 cuts C. T. C.
Treatment (3) Fifteen minutes conventional roll followed by one pass through the Disc Roller and then 3 cuts C. T. C.
Treatment (4) Normal half hour conventional roll followed by 3 cuts C. T. C.

Samples from 17 repeats of these treatments were tasted at Tocklai. The Taster's preferences were as follows :—

Treatment (1) Two passes through Disc Roller followed by 3 cuts C. T. C. - Preferred 7 times.

Treatment (2) One pass through Disc Roller followed by 3 cuts C. T. C. - Preferred 4 times.

Treatment (3) Fifteen minutes roll-one pass through Disc Roller followed by 3 cuts C. T. C. - Preferred 2 times.

Treatment (4) Half hour roll followed by 3 cuts C. T. C. - Preferred 4 times.

This machine appears to show promise as a conditioning roller for 100% C. T. C. manufacture or for dual manufacture of orthodox and C. T. C. teas. Experiments with this machine one being continued.

(ii) **Prototype Continuous Roller :**

Vertical Type : The prototype 30 cm (12") diameter Vertical Roller was tried out during the year, with minor modifications. The make of the leaf processed through this machine had been commented on by the Tocklai Tasters as being open and flakey. Results to date indicate that approximately 51% fines can be extracted from the processed leaf through a No. 6 seive after a single pass through this machine running at the following speeds :

Worm 64 r. p. m.
Rotor 34 r. p. m.

The processing time at those speeds was 4 minutes.

In view of its natural tendency to produce more fines, modifications were taken in hand to develop this machine in the following two ways :—

(1) Developing of the 30 cm (12") diameter machine to induce more cutting action on leaf.

and (2) fabrication of a 38 cm (15") diameter machine with more generous clearances and spacing of the vanes and the resistors to induce greater leaf to leaf action. Work on this project has been progressing satisfactorily.

(iii) **Continuous Green Leaf Processing Machine :**

Rotorvane :

(a) **The 15.2 cm (6")—diameter Prototype Experimental Rotorvane :**

This machine which was installed at Teesta Valley T. E. was shifted to Ging T. E. in Darjeeling. Preliminary investigations at Ging, with this machine fitted with a cone at the end of the rotor indicated that while the attachment induced better rolling action and improved the liquor characters without detrimental effect on the flavour aspect of these Darjeeling teas, dry leaf appearance of the teas was considered to be unsuitable for the existing market. The experiment was discontinued after a month.

(b) **Cone Attachment to 38 cm (15") diameter Commercial Rotorvane :** The cone attachment fitted to the end of the rotor, in substitution of three sets of vanes and resistors at the discharge end of the machine, was tried out under different manufacturing conditions throughout the season. The cones were fabricated at Tocklai and were tried out at Kakajan T.E. on orthodox rotorvane manufacture and Cinnamara T. E. on Rotorvane C. T. C. manufacture with the following results as reported by Tasters :—

"**Kakajan** Leaf Both samples are blackish brownish in appearance. The cone sample tends to be slightly reddish brownish in appearance. The Iris End Plate sample is rather smaller in size but fair make, while cone sample is rather open. The Iris End Plate sample has better bloom.

Infused leaf : Fairly bright.

Liquors : With milk and also without milk the cone sample is brighter in colour. The cone sample is brisker with some flavour and is preferred. The Irish End Plate has a little more strength with a coarse undercurrent.

The results from Cinnamara were more conclusive, in that the Tocklai Tasters preferred the teas from Rotorvane Cone/C. T. C. manufacture nine times out of the ten comparative manufactures carried out in that factory. Their general opinion on these teas being that "the normal rotorvane/C. T. C. samples have a rather greenish taste compared to the Rotorvane Cone/C. T. C. samples which are more mature".

The average nominal valuation of the teas according to Tocklai Tasters were as follows :—

Normal Rotorvane/ C. T. C.	Rs. 5.12
Rotorvane Cone/C. T. C.	Rs. 5.28

These cones were then sent to Dooars and Cachar for experiment in conjunction with C. T. C. manufacture. The samples of teas from the experiment conducted in Dewan T. E. in Cachar were sent to us very late in the season and they could not be tasted because of very high moisture content of the samples. Results from the Dooars experiment, have been very encouraging. The result of this experiment as reported by the Manager of the Central Dooars T. E. is as follows :—

"Results favour teas manufactured by the 'Cone' Rotorvane as compared to the normal rotorvane.

Checks carried out so far as regards grade percentage shows that little difference results in teas manufactured by the'Cone' and 'non-cone' manufacture".

The Calcutta and London Brokers preferences for the comparative manufacturing tests carried out in that estate on the following days are shown below :—

6. 10. 66	'Cone' preferred by Calcutta
14. 10. 66	'Cone' preferred by Calcutta and London.
8. 11. 66	'Cone' preferred by Calcutta.
20. 11. 66	'Cone' preferred by Calcutta, London and Tocklai.

The above results indicate the general overall improvement of teas obtainable from use of this attachment at the end of the rotor. Further improvement of the processing action of this attachment have been achieved by introduction of an adjustable conical sleeve into the barrel of the Rotorvane at the discharge end. Teas from this combined attachment have also shown similar results.

Chemical analysis of the teas indicated the following differences in the C. T. C. teas from 'Cone' and 'non-cone' manufacture :—

	TF	TR
Rotorvane/ C. T. C. with cone	2.27	18.85
Rotorvane C. T. C. with Iris End Plate	2.21	18.21

(c) **Experimental 38 cm (15") diameter Aluminium Rotorvane :** Experiments were also initiated this year to study the effects, if any, on teas processed through a rotorvane made of aluminium alloy sent to Tocklai by Port Engineering Works for the purpose. This experimental 38 cm

(15") diameter machine has been set up at Kamalpur T. E. on Rotorvane /C. T. C. manufacture. The machine operated for 776 hours, processed 1,36,312 kg of made tea when one of the vanes gave way. Brokers reports from Calcutta on the teas made with this machine are as follows :—

"*Leaf*	Good, grainy and even
Infused leaf	Fair to bright
Liquors	Possess useful colour and strength with some briskness.

The Tocklai Tasters comments on these teas were that "these teas are free from any taint and in general the aluminium Rotorvane C. T. C. teas have better strength and quality. The Tocklai Biochemist reported that biochemically there was no significant difference between the samples from aluminium Rotorvane C. T. C. manufacture and those from gun-metal Rotorvane C. T. C. manufacture.

The aluminium alloy used for this machine was found to be hard enough as there was no noticeable wear in the processing parts. Defective casting of one of the vanes, which tore off at the root, was the primary reason for the breakdown of this experimental aluminium rotorvane. The experiment is proposed to be continued next year with a new set of vane-segments and resistors made of a stronger and tougher aluminium alloy.

(d) **Experimental 20 cm (8") diameter Short Rotorvane :** A prototype 20 cm (8") Rotorvane was fabricated at Tocklai having only 3 sets of resistors and vane-segments and fitted with a conical sleeve and rotor-cone attachment at its discharge end. Preliminary investigations showed that even with the reduced number of vanes and resistors, leaf can be processed to very small size by this machine. Further trials are proposed for next year.

(iv) **Tocklai Continuous Roller** : The Mark II machine developed in a 38 cm (15") wide prototype form at Tocklai was sent to our Licensees, the Britannia Engineering Co's Works at Titaghur to serve as a model to be copied by them while making a commercial machine for proving trials under actual operating conditions in tea factory. The manufacturers would only start making the machine on a larger scale after successful completion of proving trials with the commercial prototype to be fabricated by them.

(E 6) **Driers :**

Continuous Tray Machines :

The 6' Commercial Prototype Continuous Tray Drier at Hunwal T. E. was thoroughly checked and it was found that there were no signs of any excessive wear and tear of its components. An independent under-ground hot-air duct from the air-heater to the feed end of the drier was fitted to this machine as directed by the Engineering and Technical Sub-Committee.

Experiment with this machine with the hot air-duct to the feed end revealed that with this air duct open, the volume of air passing through the air-heater was increased by 20% with 20% increase in the rate of fuel consumption, while teas from this method was found to be inferior to those made with the standard Tocklai Continuous Drier.

The first three commercial machines at Dighultarrang and Beesakopie factories were inspected by the Senior Research Engineer from time to time to effect further improvement in the design of the commercial machines now being manufactured by Britannia Engineering Co. Tests carried out with the commercial Continuous Tray Drier at Beesakopie showed the following results :—

Fuel consumption, evaporation and output test for Continuous Tray Tea Drier and Eastwood Direct Oil Fired Air Heater at Beesakopie T. E. Machine No. 1004 & 1005.

Date of Test	22. 7. 66
Ambient Air Temperature	80 - 81°F
Time Heater was lighted	4. 15 A. M.
Time Temperature reached 200°F	4. 30 A. M.
Time fermented leaf first put in	4. 35 A. M.
Damper opening	$\frac{3}{4}$
Time through Drier	14 mts.
Exhaust temperature	115° - 125°F
Inlet temperature	200°F
Moisture content of made tea	3%
Weight fermented leaf put in	3681 kg
Weight of dried leaf (tea)	1262 kg
Amount of T. D. oil consumed	302 litres
Rate of consumption per kg of made tea	0.24 litres
Output : made tea/hour per drier	172 kg
Evaporation kg of moisture/hour per drier	329 kg

Teas dried in these driers were invariably found to be brighter and brisker than those from the existing driers in those factories.

General :

Mr. I. McTear, Adviser to Indian Tea Association, London paid a short visit to this Department in September. Most of his time in this visit was spent in joint inspection of various Tocklai Machines under development and the commercial versions of Tocklai Continuous Tray Tea Driers manufactured by Britannia Engineering Co., and installed at Dighultarrang and Beesakopie factories with a view to improving the design and the performance of the commercial versions of these driers still further.

ADVISORY

Touring—The Senior Research Engineer visited the following estates in connection with manufacturing experiments :—

Duklingia, Hunwal, Kakojan, Ging, Goomtee, Teok, Dighultarrang, Beesakopie, Kamalpur, Borsillah, Namdang, Numalighur, Cinnamara, Hautley, Tyroon, Halem, Monabarie, Gingia, Nya Gogra, Tezpur and Gogra, Dekiajuli, Borahi and Kenduguri, Ethelwood, Haroocharai, Gatoonga and Mokrung Tea factories.

He attended one Engineering Sub-Committee meeting at Calcutta and paid routine visits to Britannia Engineering Co., and Port Engineering Works in connection with commercial manufacture of Tocklai machines. He also attended three meetings of the Academic Council and Planning and Construction Board of the Dibrugarh University.

Correspondence —522 letters and memoranda of routine and technical nature were issued during the year.

STATISTICS DEPARTMENT

Ajit K. Biswas—Statistician

STAFF

Mr. Ajit K. Biswas was appointed as Statistician from 1st July, 1966. Mr. J. D. Goswami, Junior Scientific Assistant, resigned on 8th September, 1966.

The Statistician attended courses on the electronic computer at I. I. T., Kanpur, from 27. 7. 66 to 9. 8. 66 and at I. S. I., Calcutta, from 15.11.66 to 9. 2. 67. Mr. A. R. Sarkar, Statistical Assistant, was in charge of the Department during these periods.

Mr. Asim Kanti Biswas, Statistical Assistant, attended the course on the electronic computer at I. S. I., Calcutta, from 15. 11. 66 to 9. 2. 67.

RESEARCH AND EXPERIMENT

(X 2) **Crop-Weather Studies :**

Summary

Investigations into the effect of rainfall factors on the crop harvested during July to September (main crop) in a region of Upper Assam, where average annual rainfall exceeded 2300 mm (90 inches), showed that the effect of January to March rainfall on the main crop was more beneficial at the lower level than at the higher level of this rainfall, and April to June rainfall showed an adverse effect.

The crop up to June (early crop) showed a significant positive association with the main crop and the study suggested that the rainfall during January to March was highly beneficial to the early crop which, in turn, benefitted the main crop. An additional beneficial effect of January to March rainfall on the main crop was also detected.

Investigations into the effect of rainfall on the season's crop obtained during July to September (main crop) was continued from the data for 7 years (1957-63) provided by the 57 tea estates in that region of Upper Assam where average annual rainfall exceeded 2300 mm (90 inches). This region extended over the whole of Lakhimpur district and the adjacent portion of the Sibsagar district.

Preliminary examination of the data suggested a linear relationship between the main crop (Y_m) and the season's crop up to June (early crop). Hence, the investigation was divided into two parts, namely, (a) the effect of rainfall factors on the main crop and (b) the effect of rainfall factors on the main crop in the presence of the early crop (Y_e).

(a) **Effect of rainfall factors on the main crop**—Following the study of the long-term data of Tocklai (Ann. Rep., 1964, page 104), a multiple regression of the main crop, which was about 55% of the total annual crop, on five rainfall variables were obtained from the 'within estate' and 'between year' sources of variation and covariation in crop and rainfall. These five variables were the linear and quadratic components of January to March and April to June rainfalls (R_1 and R_2 respectively) and the linear component of July to September rainfall (R_3). In order to find the most potent variables associated with the main crop, the independent variables were gradually reduced from the regression function on the basis of their relative contribution to the total regression. It was found from 'within estate' source of variation that the linear component of January to March and April to June rainfalls were the significant factors associated with the main crop. January to March rainfall was beneficial to the main crop but April to June rainfall showed an adverse effect on it. The relative contribution to the total regression due to January to March rainfall was, however, the highest. The goodness of fit was further improved when, instead of the simple linear component, the logarithm of January to March rainfall was introduced in the regression function which suggested that the effect of January to March rainfall on the main crop was more beneficial at the lower level than at the higher level of this rainfall.

(b) **Effect of rainfall factors on the main crop in the presence of the early crop**—A multiple regression of main crop on the rainfall factors log R_1, R_2 and R_3 and the early crop (Y_e) was fitted from 'within estate' and 'between year' sources of variation to find the relative contribution of the rainfall factors to the main crop in the presence of the early crop. Regression from the two sources accounted for 51% and 99% of the total variation respectively. The partial regression coefficients of Y_m on log R_1, R_2 and Y_e were all significant. The relative contribution to the total regression due to early crop was, however, the highest.

It was found from the 'within estate' source of variation that the effect of rainfall during January to March on the main crop was reduced to about half when estimated in the presence of the early crop. This suggested that the rainfall during January to March was highly beneficial to the early crop which in turn benefitted the main crop, but there was also

a direct beneficial effect of the January to March rainfall on the main crop. The partial regression coefficient of main crop on April to June rainfall was also reduced but remained to be negative and significant.

The regression analyses from the 'between year' source of variation largel supported the above findings except that the regression coefficients in some cases failed to reach significance owing to too few degrees of freedom available for the estimate of errors.

(X 3) **Survey of Shade Trees :**

Summary

Some of the results obtained from the Sample Survey of shade trees (1965-66) carried out in twenty Member estates from Nowgong, Jorhat, Nazira, Naharkatia, Dibrugarh and Panitola circles of Upper Assam during the rainy season and dry season are summarised below.

The proportion of various species used as shade varied amongst the six circles.

Over the six circles, Albizzia chinensis and Dalbergia assamica showed a definite decreasing trend in their use during the recent years while the proportion of A. odoratissima and A. procera did not follow any definite trend. The proportion of A. lebbek, Derris robusta, A. falcata and Gliricidia sepium taken together showed an increasing trend in their use (A. falcata trees were generally up to 20 years and Gliricidia sepium were all below 7 years of age).

Over-all estimate from the Rainy Season Survey data of the six circles showed that 92% of the observed shade trees of all species were affected by some pests or diseases while the corresponding estimate for the dry season was only 50%. The reduction was not observed in Nowgong circle where the percentages of affected shade trees were as high as 98% in both the seasons but appreciable reductions were detected in all the remaining five circles during the dry season.

Over the six circles, A. odoratissima shade trees were badly affected by Caterpillars, A. procera by Orange mite and A. chinensis by Canker during the rainy season. Practically no Caterpillars were found to attack the shade trees during the dry season.

Some of the results obtained from the Sample Survery of shade trees (1965-66) carried out in twenty Member estates from Nowgong (2), Jorhat (4), Nazira (3), Dibrugarh (4), Naharkatia (3) and Panitola (4) circles of Upper Assam during rainy season (1st Round- 19. 7. 65 to 27. 9. 65) and dry season (2nd Round--24. 1. 66 to 2. 4. 66) are presented below:

(a) **Use of different species of shade trees**

The analysis of the second round survey data showed that the estimates of the proportion of different species of shade trees used by the estates were more or less the same as those of the first round survey. The combined estimates from both the rounds showed that over the six circles, 37 per cent of the shade trees were *Albizzia odoratissima*, 34 per cent *Albizzia procera*, 13 per cent *Albizzia chinensis*, 8 per cent *Dalbergia assamica*, and *Albizzia lebbek*, *Derris robusta*, *Albizzia falcata* etc. constituted the rest 8 per cent of the total. The proportion of various species used as shade varied amongst the six circles. Nowgong used mostly *A. odoratissima* (71 per cent) and the Dibrugarh circle used *A. procera* (58 per cent). Jorhat, Nazira and Naharkatia circles were found to use *A. odoratissima* and *A. procera* in general. In the Panitola circle the proportion of *A. odoratissima*, *A. procera* and *A. chinensis* were 31%, 32% and 18% respectively.

The possible change with time in the use of species of trees as permanent shade was also studied from the second round survey. From the over-all position of six circles, the estimate of the proportion of shade species at different ages revealed that *A. chinensis* and *D. assamica* showed a decreasing trend while *A. odoratissima* and *A. procera* did not follow any definite trend in their use during the recent years. Further, the proportion of *A. lebbek*, *D. robusta*, *A. falcata* and *Gliricidia sepium* taken together showed an increasing trend in their use (*A. falcata* trees were generally up to 20 years and *G. sepium* were all below 7 years of age). These results were similar to those obtained from the first round survey (Ann. Rep., 1965, page 113).

(b). **Pests and Diseases of Shade Trees**

(i) **Seasonal variation of infestation of shade trees**--Estimates of the percentage of shade trees of different species affected by pests and diseases were obtained for all the six circles separately and also over-all position both for Rainy Season and Dry Season Surveys. Over-all estimate obtained from the Rainy Season Survey which corresponded to the peak period of infestation showed that almost all the observed shade trees of all species in the six circles were infested by some pests or diseases (92 per cent.) The corresponding estimate for the dry season was only 50 per cent.

In Nowgong circle the percentages of affected shade trees were as high as 98 per cent in both the seasons but in the other five circles the percentages during dry season were less compared to those of the rainy season. The maximum reduction was in the Naharkatia circle (100 per cent to 23 per cent) followed by Panitola (84 to 17 per cent), Dibrugarh (77 to 30 per cent), Jorhat (99 to 63 per cent) and Nazira (93 to 63 per cent) circles respectively.

(ii) **Prevalence of pests and diseases of shade trees**—Rainy Season Survey data showed that over the six circles 81 per cent of the *A. odoratissima* shade trees were affected by Caterpillars. Amongst other pests or diseases, Canker (58%), Red rust (56%), Borers (55%) and Termite (31%) were the most prevalent.

Shade trees of *A. procera* were highly susceptible to Orange mite (83%). Canker (66%), Caterpillars (55%), Borers (52%), Red rust (32%) and Termite (28%) were also found to attack the species considerably.

The shade trees of *A. chinensis* observed over the six circles were highly affected by Canker (80%). Borers, Caterpillars, Red rust and Termite also attacked the species, the corresponding percentages of attack being 57, 54, 34 and 28 respectively.

The percentages of shade trees of all species and over the six circles attacked by different pests or diseases were : 61 per cent each by Canker and Caterpillars, 51 per cent by Borers, 41 per cent by Red rust, 40 per cent by Orange mite, 33 per cent by Termite and 24 per cent by Membracids.

It has been mentioned above that the infestation due to all pests and diseases were much less during the dry season compared to that of the rainy season, but it was noticed that certain species of shade trees were more susceptible to certain pests or diseases in both the seasons, e. g., Canker and Orange mite on *A. procera* and Canker on *A. chinenis*.

One important observation made was that Caterpillars were practically absent during the dry season. The relative position of pests and diseases attacking the shade trees of all species and over the six circles during the dry season were : Canker (33 per cent), Borers (18 per cent), Termite (12 per cent), Orange mite (11 per cent), Red rust (8 per cent).

(X4C) **Intermittent Plucking :**

Summary

In an attempt to minimise the labour and cost of experimentation on tea, the relative efficiency of five sampling schemes were studied using data from eight experiments in the Assam valley, Dooars and Darjeeling. The object was to find out the sampling rate and the method to estimate the total yield due to a treatment, with a reasonable degree of accuracy, by recording yield for a minimum number of plucking rounds from the total. The studies showed that the sampling rate and the sampling method required in each region depended on the number of years of experimentation.

To study the efficiency of intermittent plucking, weekly yield data over six years from seven experiments—three from the Assam valley, two each from Dooars and Darjeeling and one experiment having five years data from Darjeeling were analysed. In estimating the yield due to a treatment, the relative efficiency of five sampling schemes namely (a) simple random, (b) stratified sampling when plucking occasions in the sample were allocated in proportion to the product of the size and standard deviation of the stratum, (c) stratified sampling when plucking occasions in the sample were allocated in proportion to the size only, (d) stratified sampling with one sample per stratum and (e) systematic sampling, were studied using sampling rates of 1 in 2, 1 in 3, 1 in 4, 1 in 5 and 1 in 6 pluckings. The population under study was the total number of plucking occasions during the above mentioned periods of the individual experiments. Some of the broad results are given below :

(1) In all the three experiments of the Assam valley when continued for one year, the systematic sampling and stratified sampling with one unit per stratum using a sampling rate of 1 in 2 and, when continued for 2 and 3 years, systematic sampling of 1 in 3 was found to provide an estimate of the yield due to a treatment for a margin of error of less than 10% of the population mean with a chance of 1 in 20. Further, when the experiments continued for 4, 5 and 6 years, stratified sampling with one unit per stratum using a sampling rate of 1 in 4 provided an estimate of the yield with the same degree of accuracy.

(2) In both the experiments in the Dooars, when continued for 1 and 2 years, the systematic sampling of 1 in 3 was found to provide an estimate of the yield due to a treatment for a margin of error of less than 10% of the population mean with a chance of 1 in 20. When the experiments continued for 3 and 4 years, stratified sampling with one unit per stratum using sampling rates of 1 in 5 and 1 in 6 respectively provided the same accuracy as above, but when continued for 5 and 6 years, sampling rate of 1 in 6 was required for the two sampling schemes (b) and (d).

(3) In all the three experiments of Darjeeling when continued for 3 years, systematic and stratified sampling with one unit per stratum using a sampling rate of 1 in 2 provided estimate of the yield for a margin of error of about 10% of the population mean with a chance of 1 in 20. When the experiments continued for 4 and 5 years, sampling schemes (b), (d) and (e) using a sampling rate of 1 in 2 provided estimates of the yield for a margin of error of about 10% of the population mean with a chance of 1 in 20, but when continued for 6 years, in both the experiments, stratified sampling with one unit per stratum using a sampling rate of 1 in 3 was found to provide the estimate of the yield with the same degree of accuracy.

Investigations on a large number of experiments will have to be made before any firm conclusion can be drawn.

(X 7) **Long-term Survey Experiments on Defoliation :**

Summary

The analysis of the data for the whole season of 1966 from the defoliation experiments conducted in the Dooars, showed that 'Defoliation' and 'Chemical Prophylactic' with and without palliative measure were equally effective in reducing the Red spider infestation in comparison with the plots which received no control measure or only 'Palliative' measure. The infestation in the 'Control' plots was, however, higher than the plots under 'Palliative' treatment only.

Yield under 'Chemical Prophylactic' treatment of annually pruned tea was significantly higher than its untreated 'Control'.

The analysis of data received during 1966 from the defoliation experiments conducted in the Dooars for the whole season of 1966 showed that the percentages of bushes affected by Red spider in the plots under 'Defoliation' and 'Chemical Prophylactic' with and without palliative measure were significantly less than in the plots where no control measure (control) or only 'Palliative' measure were taken. No significant difference was found amongst the plots under 'Defoliation' and 'Chemical Prophylactic' treatments with or without palliative measure. Further, the percentage of affected bushes in the 'Control' plots (19.1%) was significantly higher than in the plots receiving 'Palliative' (10.5%) treatment only. Similar results were obtained both in annually pruned tea and tea in a triennial Prune - Prune- Skiff cycle (skiffed during 1964-65 season), the average infestations being 7.4% and 8.0%, respectively.

Yield of annually pruned plots under 'Chemical Prophylactic' treatment was significantly higher than its untreated 'Control'. No other yield difference between sub-plot treatments was found to be significant both in annually pruned and deep skiffed tea. There was also no significant difference in yield between the main-plot treatments i. e., between 'Pruned' and 'Deep Skiffed' tea.

(X 8) During the year considerably increasing help was given to other Departments in the design of experiments and analyses of results. It was necessary to introduce some complex statistical designs to meet the special requirements of some of the experiments. The subsequent analyses of the results have so far justified these designs. Particular success has been achieved in reducing the experimental errors associated with miniature manufacture and the taste testing of samples.

List of experiments designed and/or analysed are given below :

A. The following experiments were designed by the department during the year 1966 :

(i) **Miniature Manufacture and Taste Testing**

1. Seven experiments of Agriculture Department
2. Three experiments of Advisory Department

(ii) **Others**

1. Expt. No. C 5 : The chemistry of tea and its valuation : (Biochemistry Department)
2. Soil Rehabilitation Experiment : (Agriculture & Soils Departments)

In addition to these, simple design for some of the departments were also done during the year.

B. The following complex and long-term experiments were analysed by the department during the year :

1. Miniature Manufacture and Taste Testing Experiments—Ten experiments
2. Expt. No. B 105 : Long-term NPK manuring of young tea (Clone): (Agriculture Department)
3. Expt. No. B 112 : Long-term NPK manuring of young tea (*Jat*) : (,,
4. Expt. No. B 110 : Long-term PK manuring (with constant dose of N) of young tea (*Jat*) : (,, ,,)
5. Expt. No. AS 39 : Long-term NPK Mg manuring of mature tea (*Jat*) : (Advisory Department)
6. Experiment on Development of Moisture Meter : (Engineering Dev. Dept.)
7. Relationship between meteorological observations as recorded by the Visual and Thermo-hygograph instruments : (Soils Dept.)

In addition to these, simple analyses of experiments for some of the Departments were also done during the year.

ADVISORY

Touring—One member of the department visited 6 tea estates in the Assam valley in connection with the survey of shade trees, and three members visited Bokahola T. E. weekly in connection with the uniformity trial.

ASSAM ADVISORY DEPARTMENT– ASSAM VALLEY : SOUTH BANK

S. K. DUTTA — Chief Advisory Officer
S. BASU — Advisory Officer
S. K. SARKAR — Advisory Officer

TOURING

The following estate visits were made by the Advisory Officers in the Assam Valley : South Bank.

Jorhat Sub-area	.....63 visits	*Doom Dooma Sub-area*	... 34 visits
Gologhat Sub-area	... 37 ,,	*Digboi-Borhapjan Sub-area*	,,
Panitola Sub-area	... 9 ,,	*Tingri Sub-area*	... 10 ,,
Dibrugarh Sub-area	... 16 ,,	*Nowgong Sub-area*	15 ,,
Moran Sub-area	... 14 ,,	*Sonari Sub-area*	... 14 ,,
Nazira Sub-area	... 16 ,,	*Nahorkatia Sub-area*	... 8 ,,

During the year practically all estates visited asked for advice on the newly introduced extended pruning cycles. Drainage was again a popular subject and it is pleasant torecord a vast overall appreciation of the necessity for drainage. Advice on use of herbicides was given frequently. Other subjects on which advices were given regularly were :—

(a) Vegetative Propagation.
(b) Spraying technique with power sprayers.
(c) Rehabilitation of uprooted areas.
(d) Establishment of shade.

The Chief Advisory Officer paid a visit to Uttarkhand and Dehra Dun between 10th - 22nd October, 1966 at the request of the Tea Board.

COURSES

Three Lecture Courses on Field Management and two on Vegetative Propagation were organised by the Chief Advisory Officer from 2nd May to 20th May '66 and 6th to 16th June, respectively. There were also four courses on Agricultural Chemicals organised by the Chief Advisory Officer and of these, two were held from 18th to 27th April '66 and the other two from 26th September to 5th October, 1966.

MEETINGS

The Chief Advisory Officer accompanied by the Director attended the following inaugural meetings of the Area Scientific Committee.

*	South Bank West	—	25th October 1966
*	South Bank East	—	31st October 1966
*	South Bank Central	—	4th November 1966
	North Bank West	—	17th November 1966
	North Bank East	—	18th November 1966

* Also attended by Mr. S. Basu, Advisory Officer.

Field Experiments

Field experiments carried out by the Advisory Department continued and are listed in Appendix A. A brief summary of the more important results is given in Appendix B.

APPENDIX A

List of Experiments

South Bank, Assam

Project	Site (T.E)	Index	Year of starting
Rehabilitation of Land	Sangsua	AS 45	1963
	Duklingia	AS 48	1964
	Ghillidary	AS 49	1964
	Hansara	AS 50	1964
N. P. K. Manuring	Murmuria	AS 11	1956
	Khoomtaie	AS 29	1959
	Ligri Pookrie	AS 39	1961
	Dekhari	AS 41	1962
	Panitola	AS 6	1954
	Hunwal	AS 51	1964
	Dirok	AS 63	1965
	Katonibari	AS 44	1963
N. P. K. Manuring Seed Bari	Cinnamara	AS 23	1959
Nitrogenous Fertiliser	Sycotta	AS 56	1954
	Sagmootea	AS 62	1965
	Joonktollee	AS 64	1966
	Nahorhabi	AS 65	1966
	Furkating	AS 69	1966
	Halmirah	AS 71	1966
	Cinnamara	AS 77	1966
	Meleng	AS 78	1966
	Borsillah	AS 79	1966
Pruning	Cinnamara	AS 12	1957
	Duklingia	AS 13	1958
Irrigation	Amluckie	AS 52	1963
	Jiajuri	AS 53	1964
	(Mature Tea)	AS 54	1964
	Jiajuri	AS 54	1964
	Towkok	AS 66	1966
	Borahi	AS 67	1966
	Gorunga	AS 68	1966
	Gabroo Purbut	AS 70	1966
	Dejoo Valley	AS 72	1966
	Dejoo Valley	AS 73	1966

North Bank, Assam

Project	Site (T.E.)	Index	Year of starting
Nitrogenous Fertilisers	Halem	AN 3	1933
	Nahorani	AN 59	1964
	Gingia	AN 80	1966
	Shakomato	AN 81	1966
	Bahi Pookrie		1966
Cultivation and Weed Control	Halem	AN 15	1958
	Halem	AN 31	1960
Irrigation	Balipara	AN 55	1963
	Sessa	AN 61	1965
	Durrung	AN 74	1966
	Mazbat	AN 75	1966
Soil Rehabilitation	Deckiajuli	AN 47	1964
	Tarajuli	AN 46	1964
	Ghoirallie	AN	1966
Pruning	Phulbari	AN 58	1964
	Ghoirallie	AN 60	1965
	Kolony	AN 76	1966

Dooars, West Bengal

Project	Site (T.E.)	Index	Year of starting
Cultivation and Weed Control	Chuapara	D. 11	1957
	Bhatpara	D. 10	1957
Shade & Manuring	Nya Sylee	D. 24	1962
N. P. K. Manuring	Kalchini	D. 1	1954
	Needam	D. 30	1963
Nitrogenous Fertiliser	Baradighi	D. 33	1966
	Good Hope	D. 29	1961
Shade	Nya Sylee	D. 9	1958
Pruning	Chuapara	D. 2	1955
	Baradighi	D. 4	1955
	Sam Sing	D. 34	1966
Rehabilitation	Grassmore	D. 28	1964
	Bhogatpore	D. 27	1964
Irrigation	Baintgoorie	D. 31	1965
	Rajabhat	D. 32	1965
	Gopalpore	D. 35	1966
Reclamation of Soils	Birpara	—	1966
	Bundapani	—	1966

Darjeeling, West Bengal

Project	Site (T. E.)	Index	Year of starting
Shade & Manuring	Nagri Farm	Dj. 19	1961
N. P. K. Manuring	Tumsang	Dj. 22	1965
	Sangnia	Dj. 23	1965
Nitrogen Fertilisers	Marybong	Dj. 28	1966
	Singell	Dj. 26	1966
	Lingia	Dj. 20	1962
Pruning	Lingia	Dj. 21	1963
	Phoobsering	Dj. 24	1965
	Maharance	Dj. 27	1966
	Goomtee	Dj. 25	1966
Plucking	Mim	Dj. 18	1961

Cachar, Assam

Project	Site (T. E.)	Index	Year of starting
Soil and Manuring (Soil Climatological Survey)	Coombergram	C. 20	1962
Pruning	Coombergram	C. 21	1961
	Longai	C. 22	1962
	Chandighat	C. 23	1962
	Silcoorie	C. 24	1962
	Silcoorie	C. 17	1960
Rehabilitation of Land	Koomber	C. 25	1964
N. P.K. Manuring	Isa Bheel	C. 26	1966
	Hattikhira	C. 27	1966
	Longai	C. 28	1966
Nitrogenous Fertilisers	Pallorbund	C. 29	1966
	Dewan	C. 30	1966
Irrigation	Roopacherra	C. 31	1966

APPENDIX B

Advisory Department Field Experiments

S. K. Dutta — Chief Advisory Officer
S. Basu — Advisory Officer, South Bank, Assam.
S. K. Sarkar— ,, ,, ,, ,, ,,
P. C. Sharma ,, ,, North Bank, Assam
T. K. Ghosh — ,, ,, Cachar, Assam.
W. J. Grice —Chief Advisory Officer, West Bengal.
H. Mitra —Advisory Officer, Darjeeling & Terai, West Bengal.
F. Rahman —Advisory Officer, Dooars, West Bengal.

Brief summaries of some of the experiments conducted by the Department in Member estates are given below :

(A. 7) **Nitrogenous Fertilisers** :

(1) **High frequency application of sulphate of ammonia**— The levels of nitrogen varied from 112 kg to 247 kg ha, applied in one dose and also in 4-8 equal monthly doses.

South Bank, Assam

In two experiments (Expts. No. AS 56 and and AS 62) levels higher than 112 kg N/ha did not bring about any significant improvement in yield whether these were applied in one dose or in 4-8 doses. The tea was deep skiffed in both cases and was high yielding, having given 2518 kg/ha and 3170 kg/ha with 112 kg N/ha (Control) in Expts. No. AS 56 and AS 62 respectively, in 1956.

North Bank, Assam

Results were same as above (Expt. No. AN 59). The tea was pruned.

(2) **Time and method of manuring :**

Darjeeling, West Bengal

In one experiment (Expt. No. Dj. 20), broadcast, half bangles and disc methods of manuring were tried. The level of nitrogen was constant at 90 kg/ha. In broadcast method, application of manure at different times and in two divided doses were also tried. The experiment had been in progress for four years in 1966. In none of the year was there any significant difference in yield between the treatments.

(A. 5) **N. P. K. Manuring :**

South Bank, Assam

In one experiment (Expt. No. AS 44) on tea replanted in 1955 a high level of phosphate and potash (each at 224 kg/ha) in conjunction with 112 kg N/ha gave significantly higher yield than 112 kg N/ha (Control) for two consecutive years. Phosphate and potash each at a low level of 22. 5 kg gave higher yield than 'Control' in the first year but failed to repeat the performance in the second year.

In another experiment (Expt. No. AS 34) on tea planted in 1949-50 a low level of phosphate and potash (each at 22.5 kg/ha) in conjunction with 112 kg N/ha failed to give higher yield than 'Control' (112 kg N/ha) over a period of five years.

In an experiment (Expt. No. AS 39) on tea replanted in 1954 both 90 kg and 135 kg nitrogen per hectare gave higher yield than 0 kg nitrogen. There was however no difference between 90 kg and 135 kg. over a period of five years (1961-'65). Potash at 45 kg per hectare gave a significant increase of 109 kg/ha per year over 0 kg potash. Main effects of magnesium (22.5 kg/ha) and phosphate (45 kg/ha) were not significant.

Darjeeling, West Bengal

In one experiment (Expt. No. Dj. 23) on mature tea of unknown age, phosphate and potash each at 2 levels of 22 and 45 kg/ha failed to show any beneficial effect on yield in the first year of the experiment. The tea was unpruned.

(A9) **Pruning :**

South Bank, Assam

In two experiments (Expts No. AS 12 & 13) both deep skiff (following a light skiff the previous season) and medium skiff (following a prune the previous season) gave significantly higher yield than a top prune.

North Bank, Assam

Complete defoliation of annually pruned tea or tea under a biennial pruning cycle of prune-deep skiff, did not result in a loss of crop over a period of two years (Expt. No. AS 58).

In one experiment (Expt. No. AN. 60) the following treatments are being tried.

1. Biennial cycle — 1st year = Skiff at 12.5 cm, pluck at above the level of skiff.
   2nd year = Prune 1 cm up; pluck at 20 cm.
2. Biennial cycle — 1st year = Skiff at 10 cm, pluck at 10 cm above the level of skiff.
   2nd year = Prune 1 cm up; pluck at 20 cm.
3. Annual prune = Prune 1 cm up; pluck over 20 cm.

First year's results showed that there was no difference in yield between the two methods of skiffing. These also did not have any effect on the crop distribution.

Cachar, Assam

Complete defoliation again made no difference to the crop when carried out in annually pruned tea or in tea under biennial pruning cycle of prune-deep skiff or prune-medium skiff, over a period of four years (Expt. No. C. 23).

Dooars, West Bengal

The following biennial pruning cycles were being tried together with annual prune (Expt. No. D. 2.).

1. Prune— light skiff
2. Prune— medium skiff
3. Prune— deep skiff

All types of skiff generally gave higher yield than prune. Pruning on 2-year old wood (i.e. when tea was pruned following a skiff) did not result in loss of crop as compared with pruning on 1-year old wood (i.e. annual pruning). The mean yield of the treatments is shown below :

Table : Mean yield of made teas in kg/ha (1955–67)

Treatments	Yield
Annual prune	1602
Prune–light skiff	1829
Prune–medium skiff	1782
Prune–deep skiff	1838

(A. 8) **Plucking :**

Darjeeling, West Bengal

In one experiment (Expt. No. Dj. 13) the following treatments were being tried.

1. Pluck to the janam throughout the season.
2. Leave one leaf at the start of first flush
3. Leave one leaf at the end of first flush (end of April)
4. Leave one leaf at the end of first flush (end April) and again at the end of second flush (end of June).
5. Leave one leaf at the end of first flush (end of April), the end of second flush (end of June) and the end of monsoon (end of September).

The tea was under a three year pruning cycle of prune,-light skiff-levelling off skiff.

Two years' results had shown that there was no gain either in the total crop or in the early season crop when most valuable teas are made by leaving a leaf at any time of the season. Leaving a leaf at the start of the first flush in fact gave significantly lower yield than plucking to the janam throughout the year in the first year of the experiment. It also resulted in a lose in the early season crop in both the years. The tea was given a light skiff in the first year and a levelling off skiff in the second.

ASSAM ADVISORY DEPARTMENT--ASSAM VALLEY NORTH BANK

P. C. SHARMA – Advisory Officer

STAFF

No change in Staff position.

TOURING

The following estate visits were made by the Advisory Officer

Tezpur Sub-area	—	31 visits
Bishnauth Sub-area	—	40 ,,
Mangaldai Sub-area	—	27 ,,
Borsola Sub-area	—	21 ,,
North Lakhimpur Sub-area	—	2 ,,
Goalpara District	—	3 ,,
Cachar District	—	9 ,,

In addition, he also paid 23 visits to estates in connexion with conducting of experiments.

Thus, a total of 184 visits were paid, the number of individual estates visited during the year being 72 only.

MEETINGS

The Area Scientific Committees North Bank East and West were inaugurated and the Advisory Officer, North Bank, attended all the meetings held during the year.

TECHNICAL REPORT

Weather and Crop :

Estates received about 25 mm of rainfall in January and between 25 and 50 mm during February. Early March was dry but about 25 mm of rainfall was received in late March. Rainfall was moderate to heavy from April to October. Rainfall varied from 6 mm to 25 mm in November and was negligible in December.

The season closed with an increase in crop as compared to 1965 in majority of estates in all sub-areas.

Pests and Diseases :

Incidence of Purple mites was observed on young tea in a few estates in Bishnauth Sub-area in January—early February.

A mild attack of Looper caterpillars was observed in most estates in Tezpur Sub-area in April and the pest was observed again in November in two estates in Mangaldai and Borsola Sub-areas, causing appreciable damage to young tea.

Incidence of Red spider was observed in many estates in Tezpur, Borsola and Bishnauth Sub-areas during April-May. Heavy infestation of Scarlet mites was observed in one estates in Tezpur Sub-area during the same period.

Young and mature teas were badly attacked by *Lawana conspersa* in all Sub-areas from May—October. Heavy shade seems to encourage the incidence of this pest.

Incidence of Black rot was severe in several estates during the period July-September.

Hail and Flood Damage :

Hail caused damage to tea in two estates in Tezpur Sub-area and in one estate in Goalpara district in March.

One estate in Mangaldai Sub-area was affected by flood in late August and heavy silting occurred in a few sections of tea.

ASSAM ADVISORY DEPARTMENT—CACHAR

T. K. Ghosh—Advisory Officer

STAFF

Dr. T. K. Ghosh, Advisory Officer took over charge of the Branch on 14th March, 1966.

Sri S. K. Paul and Sri J. M. Acharjee, Artisans were transferred from Tocklai and joined this Branch on 9th June, 1966.

Sri N. R. Chakravarty joined as driver on 20th July.

The Advisory Officer was on annual leave from 3rd October to 6th November, 1966.

TOURING

The following estate visits were made by the Advisory Officer during the year :

Happy Valley Sub-area	44	visits
North Cachar ,,	4	,,
Chutla Bheel ,,	6	,,
Hailakandy ,,	24	,,
Longai ,,	15	,,

A total of 93 visits were paid by the Advisory Officer but several estates were visited on more than one occasion. The total number of individual estates visited during the year being 32.

MEETINGS

The Director and the Advisory Officer attended the 65th Annual General Meeting of the Surma Valley Branch, Indian Tea Association on 16th February, 1966.

The Director also attended the inaugural meeting of the Area Scientific Committee meeting held on 29th November, 1966.

The Advisory Officer visited Tocklai from 8th to 14th November, 1966 to attend the officers' "Get-together".

TECHNICAL REPORT

Weather :

Except for a short spell of drought during March the early part of the first quarter received favourable rains. During early second quarter con-

siderable hail damage reduced the crop in many estates, particularly in the Chutla Bheel and Happy Valley Sub-areas. The district was flooded due to heavy rains during June and early July causing serious damage to tea in some estates and most of the roads were under water for about a month. Heavy rain continued during the early third quarter also and as a result there was a considerable loss in crop as plucking rounds could not be maintained in some of the estates during June and July. The weather remained favourable from the middle of third quarter untill the closing of the year and the district was slightly ahead in crop as compared to 1965.

Pests and Diseases :

During the early part of the year blister blight was observed in some estates. Red rust and Black rot appeared later and remained in almost all areas. Red spider continued to be the most important pest practically throughout the year except the early part. Helopeltis appeared little late this year and was observed in most of the areas.

BRANCH EXPERIMENTAL WORK

Experiments :

Pretreated cuttings of 12 different Tocklai released clones received from Tocklai during June, 1966 were propagated in V. P. beds for planting up a clonal multiplication plot.

Meteorological Station :

One Standard Raingauge received from Ramkala, Poona was installed and rainfall is being recorded since 7th August, 1966.

WEST BENGAL ADVISORY DEPARTMENT
DOOARS BRANCH

W. J. GRICE— Chief Advisory Officer
F. RAHMAN — Advisory Officer

STAFF

Mr. W. J. Grice, Chief Advisory Officer, West Bengal was away on long leave from 26th May to 28th October, 1966. Dr. F. Rahman arrived at Nagrakata on 4th February, 1966 after completing his training at Tocklai, and he proceeded on earned leave on 18th December.

M. S. Lama retired from the Association's service on 30th September. S. S. Das was appointed to replace K. M. Bhatnagar on 5th December and is under training at Tocklai. R. B. Pradhan was appointed as Clerk/typist on the 17th November.

TOURING

The Chief Advisory Officer paid a total of 25 advisory visits to gardens (all Members of T. R. A.) Details are given below :

Dam Dim Subdistrict	...	9 visits
Chalsa Subdistrict	...	1 visit
Nagrakata Subdistrict	...	2 visits
Binnaguri Subdistrict	...	4 ,,
Dalgaon Subdistrict	...	5 ,,
Jainti Subdistrict	...	2 ,,
Darjeeling	...	1 visit
Terai	...	1 ,,

The Chief Advisory Officer visited the Mal Station on 5 occasions in November and December.

The Advisory Officer paid a total of 133 advisory visits to gardens (all Members of T. R. A.) Details are given below :

Dam Dim Subdistrict	...	20 visits
Chalsa Subdistrict	...	27 ,,
Nagrakata Subdistrict	...	13 ,,
Binnaguri Subdistrict	...	22 ,,
Dalgaon Subdistrict	...	20 ,,
Kalchini Subdistrict	...	18 ,,
Jainti Subdistrict	...	13 ,,

During the year the vast majority of estates visited wanted advice on vegetative propagation and pest and disease control. The problems of establishing shade and the control of shade tree pests were also subjects on which advice was given on a number of occasions. There has also been a significant increase in requests for advice on soil matters, in particular in connection with drainage and rehabilitation.

MEETINGS

The Chief Advisory Officer attended the following Annual General Meetings :—

Terai Branch Indian Tea Association on 28th January.
Dooars Branch Indian Tea Association on 29th January.
Darjeeling Branch Indian Tea Association on 26th March.

The Advisory Officer attended the inauguration of the North Bengal Branch of the Tea Association of India on 11th March in Siliguri.

Tocklai Visits— The Chief Advisory Officer and Advisory Officer visited Tocklai for the staff "Get together" during the period 8th—11th November and in addition the Chief Advisory Officer visited Tocklai for the Lecture Courses from the 1st to 20th May.

Scientific Sub-Committees— The Chief Advisory Officer attended Scientific Sub Committee meetings of the Darjeeling and Dooars Branches of the Indian Tea Association as follows :—12th January and 25th March in Darjeeling and 19th April in the Dooars. The Advisory Officer attended two meetings of the Dooars Branch Indian Tea Association Scientific Sub-Committee on the 16th September and 31st October.

The Chief Advisory Officer attended the 1st meeting of the Terai & W. Dooars, Darjeeling and E. & C. Dooars Area Scientific Committees on the 12th, 13th and 14th December, the Advisory Officer attended the last named meeting.

TECHNICAL REPORT

Weather :

The season started much earlier than usual due to good rainfall in January and February coupled with higher than normal temperatures, but this was followed by a bad drought in March, April and most of May and

resulted in a severe set back to crop during that period. Several estates suffered from hail in March and April. July was a very wet month and this also resulted in a reduction in crop. The weather at the end of the season was good and so the back end crop made up to a certain extent the poor crop in April, May and July.

Pests :

Red spider was widespread on estates when steps to control the pest were not taken. It was observed that the pest persisted in the rains and started appearing in moderate intensity in October. Scarlet mite was bad in many estates and appears to be on the increase all over West Bengal. Incidence of purple mite in mature tea besides attacks in nurseries was reported from a number of gardens. *Helopeltis* was also reported from Kalchini, Chalsa and Dam Dim areas from October onwards. Black rot was severe on some gardens in Kalchini, Chalsa and Dam Dim areas. Cockchafer caused considerable damage to clonal tea in certain areas. Severe cricket damage on clonal tea was reported from one estate in the Kalchini area.

Shade trees continued to suffer from attacks from *Membracids*, cockchafer beetle and *Agrilus beesoni*. *Bostrichid* borers were found attacking *Albizzia moluccana* and *Derris robusta* on a number of estates.

EXPERIMENTS

Branch Experimental Works

The nucleus clones of all Tocklai release clones were made up to full strength during the year and 29,700 cuttings were released to Member estates in June and October.

During the year 4 new experiments were laid out. The cultivation experiment at Bhatpara T. E. was discontinued at the end of the year. Manures in the Baradighi manuring experiment were wrongly applied. Work on other experiments continued according to their programmes. The Chief Advisory Officer paid 36 visits to experiments and the Advisory Officer 17 visits.

A list of the experiments in progress with the year of starting is included in the Appendix A.

STATION REPORT

Visitors :

Mr. D. B. Wallace from 24th to 27th January, Mr. I. F. Morriss O. B.E., on 15th May Mr. D. Allan, Duncan Bros. on 16th December.

In addition to the above the station was visited by several local planters and representatives of Burmah Shell and I. C. I. Ltd.

Meteorological Station :

Regular readings continued to be recorded. The Met. Station was visited by Mr. B. V. Kulkarni of Indian Meteorological Department, Poona during the period 20th to 23rd September.

WEST BENGAL ADVISORY DEPARTMENT, DARJEELING & TERAI BRANCH

W. J. GRICE — Chief Advisory Officer
H. MITRA — Advisory Officer.

STAFF

Mr. H. Mitra, Advisory Officer moved to Darjeeling on the 2nd February to take over the charge of the Darjeeling and Terai Advisory Branch. Sri D. B. Chhetri was appointed in the post of Clerk/typist on 25th February 1966.

TOURING

The Advisory Officer paid a total of 187 visits to T. R. A. Member estates, details of which are given below :

Darjeeling	—	95 visits
Terai	—	52 ,,
Dooars	—	40 ,,

During visits to estates in Darjeeling advice was commonly given on; pest and disease control, in particular blister blight, scale insects and mites. It is obvious that more and more estates are becoming conscious of the need to control pests and diseases. Another subject on which advice was commonly given was pruning cycles and different degrees of skiff, it is interesting to record that more estates are incorporating different skiffs into pruning cycles with a view to even out crop distribution during the first and second flush period.

Managers on Terai estates required advice mainly on drought precautions as well as pest and disease control. The establishment and maintenance of shade was also a common topic on which advice was given.

MEETINGS

The Advisory Officer visited Tocklai from the 8th to 12th November 1966 for the "Staff Get Together" and visited the Nagrakata H. Q. as detailed below :

23rd May, 29th June, 4th & 7th July, 13th August, 11th & 12th October and 6th November.

The Advisory Officer attended the following Annual General Meetings :

Terai Branch Indian Tea Association on the 28th January, the Dooars Branch Indian Tea Association on the 29th January and the Darjeeling Branch Indian Tea Association on the 26th March.

Scientific Sub-Committee — The Advisory Officer, as the Secretary, attended the Darjeeling Branch I. T. A. Scientific Sub-Committee Meetings on the 25th March, 25th June and 26th September, and the Inaugural Meeting of the Darjeeling Area Scientific Committee of T. R. A. on the 13th December 1966.

TECHNICAL REPORT

Weather :

The climatic conditions in general were unfavourable to tea. The prolonged drought in the early part of the season, and the heavy rains which followed the drought resulted in a heavy loss in crop in many estates in Darjeeling and Terai. The season also closed early due to an unusual early cold spell. A number of estates also suffered from hail.

Pests :

Thrips was widespread and caused considerable loss to early crop on estates where necessary control measures had not been taken. Mites were active in the early part of the season and estates on the warmer aspects of the hills and in the Terai suffered heavily for not spraying at the appropriate time. The incidence of Red spider was less in the areas where regular spraying with Tedion and Kelthane from December was undertaken. It is however interesting to record that on a number of estates in the Terai and on the lower elevation Darjeeling estates Red spider appeared fairly all of a sudden in the rains.

Scarlet mite was noticeable in the Terai and on the lower elevation estates in Darjeeling district. The activities of the larvae of *Cerambycid* beetle has been on the increase in the Darjeeling East Subdistrict.

Scale insects remained active throughout the season on estates known to suffer from this pest. There is no doubt that Scale insects are responsible for more damage to tea in Darjeeling than is generally appreciated.

Diseases :

The incidence of Blister blight, according to many planters, was the heaviest for very many years and as a result, the estates prone to this disease lost a substantial quantity of crop.

Black rot was noticed for the first time on a number of estates above 1,400 metres. *Helicobasidium compactum* was also discovered for the first time on *Priotropis cytisoides* growing above 1,500 metres.

EXPERIMENTS

Field Experiments in Estates

The Chief Advisory Officer paid 13 visits and the Advisory Officer 37 visits to experiments during the year and 4 new experiments were laid out.

A list of experiments in progress during the year, is included in the Appendix A.

Factory Experiments

Manufacturing Adviser & Tea Taster and Senior Research Engineer conducted a short trial with the 6" rotorvane at Ging T. E. and also a withering experiment at Goomtee T. E.

Clonal Proving Station :

The site for the proposed Clonal Proving Station at Ging T. E. was cleared and was kept under green crops.

Meteorological Station :

A Symons type raingauge was installed at the station and regular readings continued to be recorded.

WEST BENGAL EXPERIMENTAL STATION

N. B. CHANDA—INCHARGE

STAFF

Dr. Chanda was on annual leave from 31st January to 5th March 1966.

SOIL SECTION

2496 soil samples and 6 water samples were tested and reported on for advisory purposes.

AGRICULTURE SECTION

Forty six bushes, selected on the basis of their 1965 tasting results out of three hundred forty, were again put to rooting trial and twenty eight of these to miniature manufacturing trial using leaf from the 1963 and 1964 nursery plants against a standard of Tocklai Clone 19. 29. 13. On the basis of these results as well as their field attributes, seventeen bushes, including that appear to be suitable for Darjeeling, have been finally selected for field trials by the Chief Advisory Officer. On similar considerations together with resistance to Red spider observed over a period of three years, four bushes out of twenty, located in a practically unshaded very Red spider susceptible section, were also selected for field trials. One of these, a hybrid dark leaf type, has fair vigour and plucking points with strength and quality almost similar to the 19.29 13 standard and another, of hybrid Manipuri type, has good potential for a yield clone.

Besides the twenty one bushes selected for further trials mentioned above, another big Manipuri bush has been selected which has difinite yield potential. This bush will be subjected to a rooting trial in 1967.

TOURING

The ten gardens, where the mother bushes are situated, were visited 59 times in connection with rooting and miniature manufacturing trials. In addition, four gardens were visited, once each, to collect information about a survey of Tocklai recommendations and the benefits occurred from them.

MEETING

The Officer Incharge attended the "Staff Get-Together" at Tocklai on November 9, 10 & 11.

VISITORS

A Sub-Committee of the Association with Mr. D. B. Wallace as its Chairman visited the station on January 25. And the Chairman of the Association visited the station on May 13.

CORRESPONDENCE :

490 letters, including 135 of technical nature, were issued and 1150 received.

APPENDIX

METEOROLOGICAL OBSERVATIONS DURING 1966

Summary of meteorological observations during 1966

Tocklai (Mid Assam)

(26° 47' N, 94° 12' E, 86.6 metres a.m.s.l.)

Month (1966)	Relative temperature °C					Rainfall		Daily Sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
	Mean Max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Days with 0.03 mm and above		Depth			Open Pan in mm	Penman in mm
									5 cm	15 cm	30 cm		
January	23.3 (22.3)+	10.1 (6.2)+	16.7 (15.8)+	21.5	7.9	12.7 (20.8)+	3 (3)+	6.6 (5.8)+	19.2 (19.4)+	18.4 (18.3)*	19.2 (18.9)*	36.2	67.0
February	25.4 (24.6)	13.3 (11.8)	19.3 (17.9)	29.0	7.8	30.7 (32.5)	5 (7)	6.5 (6.1)	21.7 (20.6)	20.7 (19.8)	20.8 (20.2)	54.2	90.0
March	29.2 (27.5)	17.0 (15.3)	23.1 (21.4)	34.3	12.2	30.7 (83.8)	7 (11)	3.7 (6.7)	25.0 (24.1)	23.8 (23.0)	23.8 (23.0)	88.5	138.0
April	29.4 (28.7)	19.3 (18.9)	23.8 (23.8)	33.6	16.8	311.4 (136.2)	17 (12)	5.3 (5.8)	26.8 (27.2)	25.5 (25.9)	25.4 (25.6)	105.0	143.3
May	30.8 (29.9)	24.0 (21.7)	26.9 (25.8)	35.4	20.5	245.2 (287.6)	17 (20)	5.6 (4.9)	30.0 (28.3)	28.9 (27.4)	28.8 (27.3)	108.5	165.6
June	29.4 (31.6)	23.1 (24.1)	26.1 (27.8)	34.3	20.8	371.8 (322.1)	27 (23)	2.8 (4.5)	29.1 (30.7)	28.2 (29.6)	28.3 (29.4)	75.0	125.1
July	32.0 (32.3)	25.2 (24.5)	28.6 (28.4)	31.2	23.8	177.5 (387.6)	23 (25)	4.2 (4.8)	31.6 (31.6)	30.6 (30.6)	30.4 (30.4)	99.2	149.4
August	31.4 (32.0)	24.9 (24.7)	28.1 (28.2)	31.2	23.5	355.3 (341.4)	26 (23)	1.2 (5.0)	31.3 (31.3)	30.5 (30.5)	30.6 (30.3)	83.7	146.6
September	30.5 (31.3)	23.9 (22.8)	27.2 (27.6)	33.4	22.3	(274.1) (254.2)	17 (19)	5.0 (5.0)	30.4 (31.1)	29.6 (30.2)	29.8 (30.2)	72.0	131.9
October	28.8 (29.3)	19.9 (20.5)	24.3 (25.1)	31.3	17.1	78.5 (117.6)	8 (12)	7.0 (5.4)	27.6 (28.7)	27.1 (28.0)	27.5 (28.1)	68.2	120.5
November	27.3 (26.2)	17.6 (15.0)	22.4 (20.6)	29.7	14.3	3.6 (28.2)	2 (4)	6.1 (6.0)	25.1 (24.1)	24.6 (23.6)	25.0 (24.5)	47.9	82.8
December	23.9 (23.3)	10.5 (10.6)	17.2 (17.0)	26.2	6.5	4.3 (10.9)	2 (3)	6.7 (5.8)	20.2 (20.2)	19.8 (19.8)	20.3 (20.8)	37.9	60.5

Notes : (i) Date in brackets show previous averages (+ averages of 44 to 48 years, *averages of 9 to 11 years)

(ii) Soil temperature at different depths are the mean of morning and afternoon readings

(iii) "Penman" in mm equals the Penman estimate of evaporation from an open water surface, E_0.

Summary of meteorological observations during 1966

Table 2 : Silcoorie (Cachar)

(24° 50' N. 92° 48' E. 39.6 metres a. m. s. l.)

Month (1966)	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
									Depth			Open pan in mm	Penman in mm
	Mean max.	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		5 cm	15 cm	30 cm		
January	25.7	12.0	18.8	27.2	9.4	18.0	2	7.3	21.4	20.5	21.0	54.7	79.4
	(26.1)	(10.7)	(18.4)			(19.9)	(2)	(8.2)	(21.6)	(20.8)	(21.5)		
February	29.1	15.8	21.4	31.5	9.8	16.8	2	9.2	24.7	23.4	23.6	90.3	112.4
	(27.0)	(12.6)	(19.8)			(59.9)	(5)	(7.6)	(23.0)	(21.8)	(22.2)		
March	30.4	16.7	23.6	34.9	12.2	63.7	6	8.4	26.4	25.2	25.2	121.3	153.5
	(30.8)	(16.4)	(23.6)			(103.4)	(7)	(7.8)	(26.8)	(25.4)	(25.4)		
April	32.5	20.7	26.6	35.1	18.1	187.8	12	8.8	29.8	28.6	28.3	138.3	183.9
	(32.4)	(20.7)	(26.6)			(225.4)	(13)	(7.8)	(30.1)	(28.6)	(28.4)		
May	31.8	23.0	27.4	35.2	20.3	622.9	19	6.4	30.6	29.8	29.7	140.4	173.0
	(31.8)	(22.7)	(27.2)			(394.6)	(19)	(6.4)	(30.6)	(29.4)	(29.4)		
June	29.4	24.0	26.7	34.0	20.4	1027.3	27	2.2	28.6	27.8	27.6	98.4	115.9
	(31.7)	(24.5)	(28.1)			(574.1)	(24)	(4.2)	(30.6)	(29.7)	(29.6)		
July	30.9	25.0	28.0	35.4	23.4	660.6	27	3.8	30.7	30.0	29.8	97.8	144.6
	(32.3)	(24.9)	(28.6)			(506.7)	(27)	(4.5)	(31.4)	(30.5)	(30.6)		
August	30.7	24.9	27.8	33.4	24.0	589.8	25	4.1	31.1	30.4	31.3	110.0	142.3
	(32.2)	(24.9)	(28.6)			(388.2)	(25)	(4.7)	(31.4)	(30.6)	(30.6)		
September	31.2	24.2	27.7	33.8	22.7	543.0	17	6.2	31.4	30.2	30.2	107.1	147.1
	(32.5)	(24.6)	(28.6)			(335.8)	(18)	(5.5)	(31.2)	(30.4)	(30.4)		
October	29.8	21.4	25.6	33.2	18.6	288.2	8	7.3	29.0	28.0	23.2	86.5	132.2
	(34.2)	(22.6)	(26.9)			(226.5)	(12)	(6.2)	(29.4)	(29.0)	(29.2)		
November	29.4	18.9	24.2	31.6	15.4	32.1	3	7.2	27.1	26.5	26.8	75.5	103.2
	(29.3)	(16.8)	(23.0)			(14.3)	(2)	(8.3)	(22.4)	(25.4)	(26.0)		
December	25.6	12.9	19.2	29.5	9.2	47.0	2	6.9	21.5	21.4	22.2	51.2	76.7
	(27.0)	(12.7)	(19.8)			(6.6)	(1)	(7.9)	(22.8)	(22.4)	(23.2)		

Notes : (i) Data in brackets show previous averages (averages of 9 years)

(ii) Soil temperature at different depths are the mean of morning and afternoon readings.

(iii) "Penman in mm" means Penman estimate of evaporation from an open water surface, E_o.

Summary of meteorological observations during 1966

Table 3 :- Nagrakata (Dooars)

(26° 54' N, 88° 55' E. 228.6 metres a. m. s. l.)

Month (1966)	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
									Depth				
	Mean max	Mean min.	Mean	Highest	Lowest	Monthly in mm	Day with 0.03 mm and above		5 cm	15 cm	30 cm	Open pan in mm	Penman in mm
January	24.0 (23.8)	10.7 (10.5)	17.4 (17.2)	26.3	8.6	38.2 (8.7)	3 (2)	8.4 (8.4)	18.6 (17.8)	18.6 (17.8)	19.4 (19.2)	78.4	74.3
February	26.4 (25.8)	14.2 (13.3)	20.3 (19.6)	30.3	10.3	21.0 (30.0)	2 (4)	7.1 (7.8)	21.4 (19.8)	20.9 (19.4)	21.6 (20.4)	91.9	93.5
March	30.6 (29.2)	17.0 (16.2)	23.8 (22.7)	34.3	10.6	9.7 (42.8)	2 (5)	8.0 (7.9)	25.5 (23.3)	24.6 (22.6)	25.0 (23.2)	179.2	151.4
April	32.5 (31.4)	20.5 (20.2)	26.5 (25.8)	36.5	16.5	86.6 (115.9)	11 (9)	8.2 (7.3)	28.4 (27.0)	27.2 (26.1)	27.8 (26.6)	214.0	181.7
May	32.5 (30.8)	22.5 (21.6)	27.5 (26.2)	37.5	19.1	214.7 (281.4)	14 (20)	7.0 (6.5)	29.8 (28.4)	27.2 (27.7)	29.3 (27.9)	205.8	188.8
June	30.3 (30.6)	23.2 (23.4)	26.8 (27.0)	34.1	21.5	800.5 (916.2)	25 (26)	3.5 (3.7)	28.8 (28.6)	25.7 (28.1)	28.6 (28.2)	110.0	139.4
July	30.1 (30.3)	23.4 (23.8)	26.8 (27.0)	33.8	20.9	1306.4 (949.3)	29 (27)	3.8 (3.3)	29.2 (29.2)	25.4 (28.7)	28.0 (28.8)	107.9	138.8
August	29.8 (30.4)	23.5 (23.6)	26.6 (27.0)	33.3	21.3	1125.9 (775.6)	31 (27)	3.4 (4.0)	28.4 (29.4)	25.6 (28.8)	28.5 (29.0)	97.3	127.5
September	30.4 (30.7)	22.1 (22.9)	26.2 (26.8)	32.2	18.6	616.3 (519.3)	22 (21)	5.9 (5.5)	28.2 (29.2)	? (28.8)	28.2 (25.0)	124.8	135.6
October	29.2 (29.9)	18.3 (19.8)	23.8 (24.8)	32.5	14.9	135.8 (157.1)	12 (10)	8.0 (7.6)	25.8 (27.2)	? (27.6)	26.4 (27.6)	104.2	126.9
November	27.8 (27.1)	15.2 (14.6)	21.5 (20.8)	30.4	11.3	1.9 (17.5)	2 (3)	7.7 (8.7)	22.6 (22.6)	? (22.8)	24.6 (24.0)	88.9	90.5
December	25.2 (24.8)	11.4 (11.7)	18.3 (18.2)	27.0	8.9	4.6 (4.8)	1 (2)	9.0 (8.5)	19.6 (19.4)	? (19.6)	21.4 (21.6)	78.2	75.6

Notes :- (i) Data in brackets show previous averages (averages for 7 years)
(ii) Soil temperature at different depths are the mean of morning and afternoon readings
(iii) "Penman in mm" means Penman estimate of evaporation from an open water surface, E_o
(iv) ? indicates instrument out of order.

Summary of meteorological observations during 1966

Table 4 : Nagri Farm (Darjeeling)

(26° 55′ N, 88° 12′ E, 1,250.2 metres a. m. s. l.)

Months (1966)	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature (under grass) °C			Monthly evaporation	
	Mean max.	Mean min	Mean	Highest	Lowest	Monthly in mm	Day with 0.05 mm and above		Depth			Open pan in mm	Penman in mm
									5 cm	15 cm	30 cm		
January	14.9	5.7	10.3	18.1	7.0	15.8	4	6.6	13.6	12.9	13.9	58.9	55.3
	(15.7)	(7.8)	(11.8)			(25.5)	(2)	(6.6)	(12.8)	(12.5)	(13.8)		
February	16.9	11.2	14.0	20.2	8.5	36.0	5	5.4	15.7	14.6	15.0	56.0	70.3
	(17.4)	(7.6)	(13.5)			(19.3)	(4)	(6.2)	(14.5)	(13.7)	(14.4)		
March	21.9	14.2	18.0	26.4	10.8	0.0	0	7.3	20.8	18.9	18.7	130.2	130.9
	(20.9)	(12.6)	(16.8)			(50.1)	(5)	(7.0)	(18.3)	(17.0)	(17.2)		
April	25.6	16.7	21.2	27.4	12.5	69.1	6	7.2	23.4	21.8	21.5	151.9	151.0
	(23.4)	(15.8)	(19.6)			(82.0)	(9)	(5.9)	(21.4)	(20.1)	(20.0)		
May	26.1	18.5	22.3	29.4	15.5	97.6	14	5.5	25.3	23.8	23.4	120.9	149.9
	(23.6)	(17.0)	(20.3)			(225.3)	(19)	(5.2)	(23.1)	(21.9)	(21.8)		
June	24.5	18.9	21.7	26.3	17.2	668.5	23	3.4	25.3	24.0	23.9	69.0	119.9
	(23.9)	(18.2)	(21.4)			(463.9)	(25)	(2.8)	(24.0)	(23.4)	(23.1)		
July	25.5	19.2	21.4	25.7	18.0	821.7	27	2.1	24.7	23.5	23.7	65.2	107.0
	(24.0)	(19.2)	(21.6)			(645.9)	(27)	(2.4)	(24.6)	(23.8)	(23.7)		
August	25.5	19.9	21.2	26.3	17.7	632.4	28	1.9	24.4	23.7	24.0	49.6	100.0
	(24.4)	(19.1)	(21.8)			(567.6)	(25)	(3.2)	(24.9)	(24.1)	(24.6)		
September	23.6	17.8	20.7	27.6	15.6	230.6	19	4.1	23.7	22.8	23.2	57.0	105.8
	(24.2)	(18.4)	(21.3)			(325.7)	(20)	(4.3)	(24.1)	(23.4)	(23.5)		
October	23.4	14.7	19.0	27.6	13.5	22.7	9	6.7	21.3	20.5	21.3	62.0	105.9
	(22.8)	(15.9)	(19.4)			(97.9)	(3)	(6.4)	(21.7)	(21.2)	(21.7)		
November	22.3	12.7	17.5	23.3	9.1	7.4	4	6.5	19.0	18.0	19.2	54.0	77.0
	(19.6)	(11.7)	(15.6)			(15.7)	(2)	(7.3)	(17.5)	(17.2)	(18.4)		
December	16.5	9.1	12.8	19.8	7.2	10.2	1	6.8	15.0	14.2	15.9	46.5	53.2
	(17.3)	(9.2)	(13.3)			(3.1)	(1)	(7.0)	(14.5)	(14.2)	(15.5)		

Notes : (1) Data in brackets show previous averages (averages for 5 years)

(2) Soil temperatures at different depths are the means of normal and afternoon readings.

(3) "Penman" in mm" for the Penman's estimate of evaporation from an open water surface, E$_o$.

Percent Relative humidity
Table : 1(a) Tecklai

Hours of observations. I. S. T	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
08 13	95 (97)	94 (95)	92 (95)	89 (91)	92 (89)	94 (93)	91 (94)	94 (95)	96 (95)	95 (97)	95 (98)	96 (98)
13 13	54 (58)	52 (56)	45 (55)	50 (64)	63 (72)	77 (75)	72 (75)	74 (75)	71 (75)	66 (73)	63 (65)	57 (62)

Table : 2(a) Silsoria

Hours of observations I. S. T.	Jan.	Feb.	Mar.	Apl.	May	Jun	July	Aug.	Sept.	Oct.	Nov.	Dec.
06 19	99 (98)	98 (96)	94 (93)	91 (90)	92 (91)	95 (95)	96 (95)	96 (95)	96 (95)	97 (97)	98 (97)	96 (98)
13 19	50 (55)	38 (46)	30 (47)	51 (54)	65 (68)	83 (76)	75 (75)	78 (74)	72 (71)	65 (59)	58 (55)	54 (43)

Note : Data in brackets show previous averages (averages of 7—12 years)

Percent Relative humidity

Table : 3(a) Nagrakata

Hours of observations I. S. T.	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
06 34	86 (83)	85 (81)	71 (74)	69 (75)	81 (87)	95 (95)	98 (95)	99 (95)	94 (95)	89 (89)	8- (85)	87 (85)
13 34	53 (50)	51 (51)	37 (47)	47 (53)	59 (72)	85 (88)	85 (88)	84 (82)	78 (78)	68 (68)	61 (59)	53 (55)

Table : 4(a) Nagri Farm

Hours of observations I. S. T.	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
06 37	76 (72)	77 (69)	60 (63)	62 (69)	76 (80)	90 (93)	95 (94)	98 (94)	90 (88)	76 (78)	69 (70)	69 (70)
13 37	82 (78)	74 (65)	55 (60)	64 (67)	78 (83)	88 (90)	92 (91)	93 (88)	89 (86)	82 (81)	79 (75)	72 (71)

Note : Data in brackets show previous averages (averages of 7–12 years)